Research paper

No. 3.

DEVELOPMENT of an URBAN CORRIDOR SYSTEM TORONTO TO STRATFORD AREA 1941 — 1966

by
LORNE H. RUSSWURM

DEPARTMENT OF GEOGRAPHY
and
PLANNING AND RESOURCES INSTITUTE
UNIVERSITY OF WATERLOO

Ontario

REGIONAL DEVELOPMENT BRANCH
DEPARTMENT OF TREASURY AND ECONOMICS

DEPARTMENT OF TREASURY AND ECONOMICS
REGIONAL DEVELOPMENT BRANCH

RESEARCH PAPER No.3

DEVELOPMENT of an URBAN CORRIDOR SYSTEM TORONTO TO STRATFORD AREA 1941 – 1966

by
LORNE H. RUSSWURM

DEPARTMENT OF GEOGRAPHY
and
PLANNING AND RESOURCES INSTITUTE
UNIVERSITY OF WATERLOO

1970

FOREWORD

With the increasing expansion of cities, concepts like megalopolis (Gottmann, 1961), the regional city (Carver, 1962, Kaplan, 1965, Senior, 1968), axes of development (Friedmann and Alonso, 1964), and city systems (Berry, 1964) have increasingly been stressed. All these concepts recognize that the urban form known as the city is changing. The urban form now developing, whatever it is to be called, is more and more a dynamic force organizing the land space of industrialized countries.

As urban interactions and linkages spread out over land space, the role of transportation increases in importance. Concomitant with this increased importance of transportation is the development in some areas of a more linear type of city development. Such developments have been termed corridors and some research on certain facets of this type of development has been done (Cutler, 1965, Doxiadis, 1966, Russwurm, 1964, Whebell, 1961, 1969). Because of this peculiar distribution of population and settlements found in Canada, such corridors appear to be unusually important. In light of the increasing scope and occurrence of such presumed corridor systems, research is demanded on the ways and means by which such systems, are organized. This research in the Toronto to Stratford area is aimed at providing better knowledge of the elements involved, and at tracing effects on our land space. Since corridor urban systems are developing in Southern Ontario, research on the early phases of such developments is necessary so that unnecessary problems can be avoided by sound urban and regional planning approaches which recognize such systems.

Present and previous research in the Toronto to Stratford area has not to date been concerned with the total urban system and its interaction over land space. My own research on the Hamilton to London corridor area 1941-1961 convinced me of the need to further expand such studies in a systems framework to permit model development and prediction. The work on the Hamilton to London area is also being updated; completion of that study in combination with the Toronto to Stratford study will provide valuable information on the two urban corridor areas of Southwestern Ontario.

The focus of the research is primarily on the locational structure of the developing corridor urban system with a somewhat lesser emphasis on the interactional structure or the flow elements. A system is conceptualized as a functional entity consisting of interrelated parts; flows of people, goods, and messages link the parts of the system; attributes of the parts and of the flows characterize the structure of the particular system. Considerable headway was made on establishing the structure of the corridor urban system for 1941 and 1966. The analysis of the 1941 and 1966 system structure also provides some useful predictive possibilities. Moreover, the analytical findings and the predictive aspects of the study help provide a critical knowledge whereby the regional government reports on Halton-Peel, Waterloo and other regional government studies can be further evaluated.

This study marks the first major use of township assessment rolls as a data source for a set of variables which could be quantitatively analysed to provide cartographical and statistical measures of the expansion of urbanization in an urban corridor area. A

somewhat related study, The Lake Erie Project, also supported by the Regional Development Branch, Ontario Department of Treasury and Economics and also using township assessment roll data, focusses more on data storage and data retrieval.

I acknowledge the full-time research assistance of Ken McLeary, Glenn Meyer, Ray Simpson, Harold Swierenga, Lindsay Ward and Blake Wretham, in gathering the raw data during the summer of 1967. Part-time assistance in compiling the data was given by Fred Hill, Phil Hoekstra, Mel Plewes and Grafton Ross during 1968. Also, during the analysis stage in 1969, the assistance of Ian Bender, Fred Hill, Dave Sterrett, Blake Wretham, and Lola Russwurm is particularly acknowledged. Brent Beach provided much of the computer programming assistance needed. Al Hildebrand provided needed advice and technical assistance on cartography.

All government agencies contacted readily co-operated. I note the help given by The Department of Highways, The Community Planning Branch, Department of Municipal Affairs, and the Regional Development Branch, Department of Treasury and Economics, whose support made the study possible. Finally, the willing co-operation of the staff of the various township assessment offices is acknowledged.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIXES

PART I

A SPATIAL APPROACH TO URBAN SYSTEMS

An Urban Systems Approach

Based on the operational concept of a system as a functional entity consisting of interrelated parts, the following outline of an urban systems approach is presented. The approach uses the notion that the parts of the system can be treated as sub-systems of smaller and smaller scale; that the flows of people, goods, and messages link the sub-systems and the total system; that the attributes of the parts and of the flows characterize and can be used to describe the structure of the particular sub-system or the total system. Any urban system is, of course, an open system.

Using this approach, the urban system is divided into two major spatial sub-systems identified as the internal spatial structure and the external spatial structure. Each of these two major sub-systems is sub-divided into locational and interactional sub-systems which provide a manageable means for describing, analysing, and modelling the complexity of the urban system. These sub-systems are discussed prior to the internal and external spatial structure.

The locational sub-system consists of elements having distinctive locational characteristics in land space. Using the framework proposed by Haggett (Haggett, 1965), these elements can be categorized as surfaces, nodes, paths and networks. These elements apply to both the internal and external spatial structure of cities. Some examples of surfaces are population densities, land value and residential patterns. Examples of major nodes in the internal spatial structure are the Central Business District, shopping centres or industrial basins; the nodes in the external spatial structure are the cities, towns and villages. Surfaces provide a generalized measure of the locational patterns of the urban spatial structure; the major nodes are the internal and external organizing elements and by using smaller and smaller sub-systems, the individual household, commercial or any other activity establishment (Hemmens, 1966), also becomes a node at a finer scale.

Connecting the nodes are the paths; that is, the roads, the railways, the subways, the telephone lines, and the other communication paraphernalia which characterize a modern industrial economy. These paths are aggregated into the network which provides the locational links for the total urban system.

The interactional sub-system consists of the final element of Haggett's framework, movement or flows. These flows occur between the major and minor nodes, using the paths which make up the network. Flows are the element which, above all other elements, characterize the modern urban system, whether it be the internal or external spatial structure (Simmons, 1968). A specific approach to the analysis of flows in the external spatial structure is presented in some detail below. Data to fully outline the structure of the interactional sub-system are often incomplete for the present and almost totally lacking for the past.

The internal spatial structure of urban places deals primarily with what goes on within the built-up urban area. Of typical concern, are such parts of the total system as the people, their land use activities, and all the attributes and flows that go with people and their land use; that is, the locational and interactional sub-systems. An equally useful way of looking at the internal spatial structure of cities, is the model suggested in a study of Toronto (Murdie, 1969). In this model, the internal spatial structure of cities is divided into two sub-systems of physical space and social space. This division tends to place lesser emphasis on the interactional sub-system but emphasizes a further subdivision of the locational sub-system. Regardless of whether the locational and interactional division or the physical and social space division is used, the smallest sub-system which make up the larger system are still the households or other activity establishments.

In a modern urban industrial economy, the organizational influences organizing the economy and thus the use of land space and resources emanate from the urban centres. It is this external spatial structure of cities which is the second major sub-system recognized in my approach to an urban system. From and between the nodes of the cities, towns and villages, emanate the flows which organize the land space matrix surrounding the nodes. These flows combined with the internal locational structure of the urban nodes, organize the nodes themselves into a hierarchy which makes up the urban system of a country or region. In the context of a systems approach, each node can be treated as a sub-system with its own internal spatial structure (Berry, 1964).

To date, the only book which fully combines both internal and external sub-systems of urban systems is *Issues in Urban Economics* (Perloff and Wingo, 1968). In fact, the distinction between internal and external spatial structure is used as the main organizing concept. Three recent essays under the guidance of Berry, (Berry, 1968, Berry, Goheen and Goldstein, 1968, Berry and Schwindt, 1968), have also emphasized significant aspects of the external spatial structure within a systems context, and a group of researchers at the University of Toronto, under the direction of Bourne, are utilizing an urban systems framework in studying the Ontario-Quebec urban system of cities (Bourne and Baker, 1968, Bourne, 1968, Bunting and Baker, 1968, Golant and Bourne, 1968). Since the present study deals only with the external spatial structure, a detailed outline of a suggested systems approach is given only for the external sub-system.

The External Spatial Structure: A Systems Approach

The Locational Sub-system

1. Population and Settlement Distribution

    (a) The total external system
        (i) population potential models
        (ii) metropolitan dominance and distance decay
        (iii) central place hierarchies

    (b) The individual node
        (i) external population density surfaces and gradients

2. The Land Space Matrix

   (a) The urban fringe and its characteristics

   (b) The rural to urban land conversion process

   (c) The spatial organization of the land space matrix
      (i) land use patterns
      (ii) non-farm land ownership patterns
      (iii) assessment and land value patterns
      (iv) spatial relationships of surfaces, nodes, paths, networks and the land space matrix

3. The Urban Impact on Agriculture

   (a) Urban sprawl and urban shadow effects

   (b) Urban impact on agricultural land—myths and realities

   (c) Urban impact on the agricultural structure

4. Form and Function in Expanding Urban Systems

   (a) Urban growth and urban competition in the context of a larger (national or regional) space economy

   (b) Concepts of urban form—megalopoli, regional cities, dispersed cities, corridor cities

   (c) The changing functions of a system of cities over time and space

   (d) Comparative factor analyses of cities of a regional or national system over time

   (e) Changing functions of towns and villages over time in regions of expanding urbanization, corridor and non-corridor

   (f) Central place systems and expanding urbanization.

The Interactional Sub-system

1. Flows of People

   (a) Movement of residence (or migration)

   (b) Movement to work

   (c) Movement for goods and services

   (d) Movement for social activity

2. Flows of Traffic

   (a) Traffic flows and urban hierarchies, urban corridors and megalopoli

   (b) Traffic flows and outdoor recreational areas

3. Flows of Goods

   (a) The movement of commodities into, out of, and between urban places for all human activities

4. Flows of Messages and Ideas

   (a) Messages and spheres of urban influence

   (b) Messages and urban hierarchies

   (c) Diffusion of innovations

   (d) Urbanism as a way of life.

As the Table of Contents indicates, many aspects of the locational and interactional sub-systems of the external spatial structure, were at least partially researched for the Toronto to Stratford urban corridor system. As usual, because of data problems, the flow or interactional sub-system is not nearly so well described as is the locational sub-system. Techniques for the synthesis of the locational and interactional sub-systems now exist and will be increasingly applied in the future (Berry, 1968 A,B.), as better flow data become available. The outline above served as a general guide for a research design for this study. Specific research hypotheses are presented as part of the specific analyses which follow.

PART II

THE STUDY AREA

Delimitation

My previous research indicated the presence of two major developing urban corridors in Southwestern Ontario (Russwurm, 1964). One is the Hamilton to London corridor; the other is the Toronto to Stratford corridor. Respectively, the corridor highways are Highways 2 and 7 with Highway 401 probably the transportation focus around which the corridors will merge. The Toronto to Stratford corridor already merges in the area south of Highway 7 between Burlington and Toronto where Highways 2, 5, and the Q.E.W. reinforce the transportation paths. It is in this area where the major influence of Toronto is also evident.

Since the southern boundary of the study area was already pre-defined by my study of the Hamilton to London corridor, and the eastern boundary by Metro Toronto, only the northern and western extent of the area had to be delimited (See Figure 1). Townships were used as the areal units for delimiting the study area. To the west, townships were included which would merge the corridor into the London zone of influence; to the north, enough townships were included so that the areal extent of the study area extended well beyond what was considered the probable extent of the corridor area. In my study of the Hamilton to London area (Russwurm, 1964), a map of population change 1941 to 1961, was prepared and clearly showed the lack of population growth immediately north of Kitchener-Waterloo and Guelph, thereby providing a minimum operational limit for the northern boundary of the Toronto to Stratford corridor. The cartographic analysis presented in Part II, clearly shows that the area studied extended well beyond the urbanizing corridor which still generally ends just north of Kitchener-Waterloo and Guelph.

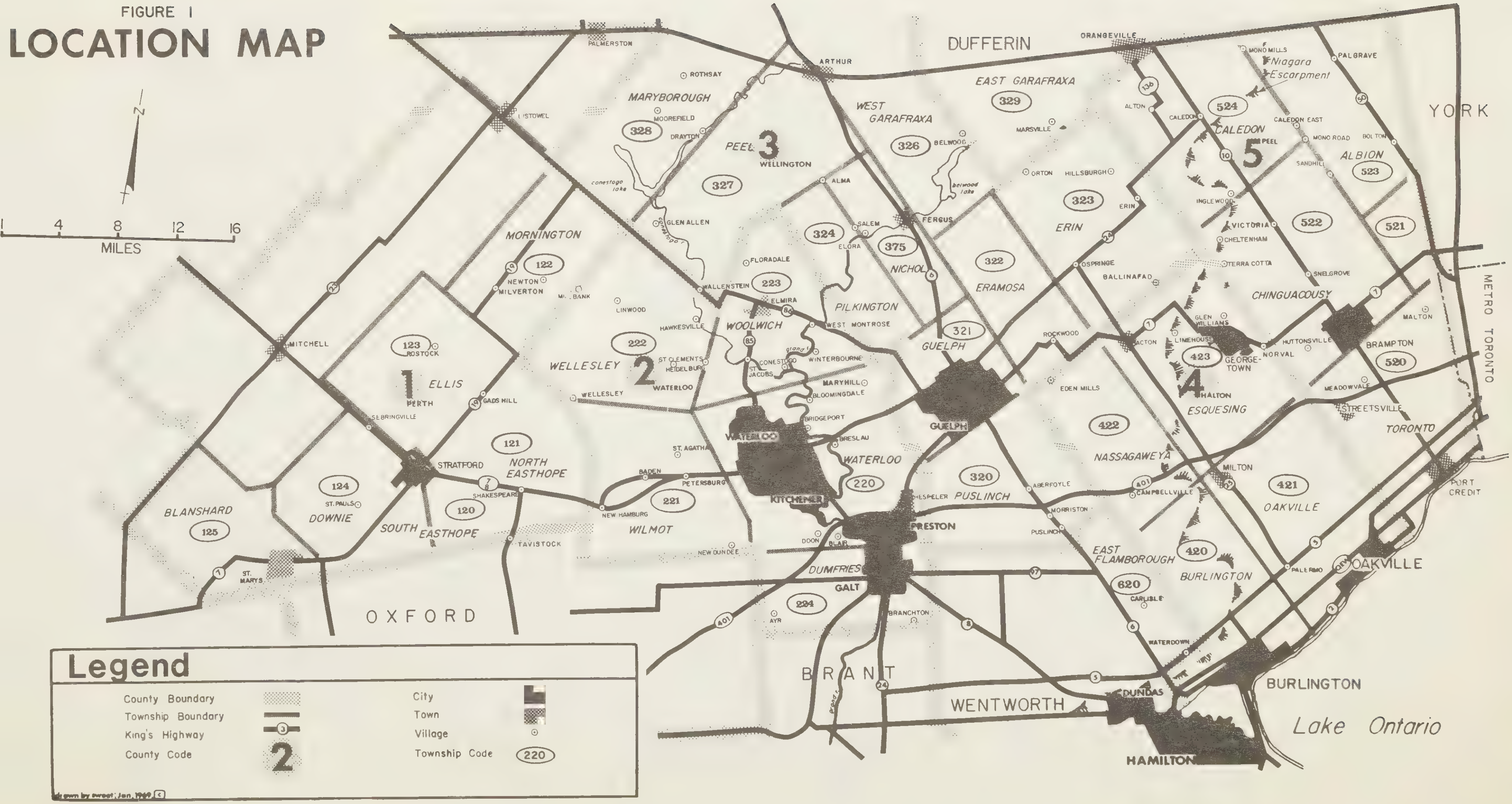
The term corridor implies a linear form. If the urban corridor system is real, wherever cities are aligned, the urbanization elements need to show a greater concentration along the direction of alignment then perpendicular to it. In terms of the systems approach outlined in Part I, the flows and the locational aspects investigated in the Toronto to Stratford area should, hence, be in the east-west direction.

Some Pertinent Population Aspects

As defined above, the Toronto to Stratford area is a linear area, approximately 90 miles by 40 miles, extending from west of St. Mary's to the boundary of Metro Toronto. It comprises all of Peel, Halton and Waterloo counties and parts of Perth, Wellington, Wentworth and Dufferin counties and consists of 31 townships. Its total area is approximately 2,500 square miles. Included within the area are ten incorporated cities, ranging in population (1966) from 12,000 to 93,000, and eight incorporated towns with populations (1966) ranging from 4,000 to 8,500. Four of the cities and one town (Kitchener, Waterloo, Galt, Preston, Hespeler) are included in the Kitchener metropolitan area with a 1966 population of 192,000.

FIGURE I

LOCATION MAP



Legend

County Boundary		City	
Township Boundary		Town	
King's Highway	3	Village	
County Code	2	Township Code	220

drawn by sweet, Jan. 1969 ©

Seventy-three village nodes have also been defined in the study area as places having three commercial functions in both 1941 and 1966. A number of other places called hamlets, having fewer than three commercial functions in either or both of 1941 or 1961, exist, but are included as part of the land space matrix for analysis.

Major aspects of the population growth of the study area are presented in Table 1. Note that the beginning time period of 1941 is prior to any major urban development in this area and this serves as a cross sectional comparative control.

The critical fact is the rapid population growth of the study area, even though much of the western and northern part of the area is predominantly rural with slow growth characteristics. For instance, the study area grew 165 per cent while western Ontario[1] grew only 96 per cent and all of Ontario only 84 per cent from 1941 to 1966. Even York County, including Metro Toronto, grew only 112 per cent in this time period. In this same time period, the Hamilton to London area grew at about the same rate as Ontario at 85 per cent. If the slower growing western and northern areas are not included, then the population growth rate of what is really the corridor area increases to 203 per cent from 1941 to 1966. Certainly the network of highways radiating westward from Toronto towards the Grand River Triangle, provides much of the impetus for the major pressures of urban development in this part of the study area.

Previous Research

Research specifically dealing with the study area is limited in amount, scope, and quality. Mostly, it consists of B.A. and M.A. theses done in the Departments of Geography at the Universities of McMaster, Toronto, and Waterloo. Such thesis research has been evaluated only to 1968, except for the University of Waterloo, for which some 1969 work is also included. A number of selected theses are briefly evaluated below; others are listed in the bibliography

Three theses of those dealing with the general geography of specific townships, are briefly discussed below; most of these were completed at the University of Toronto and McMaster University. Alderdice provides a description of Albion Township using physiographic areas and stressing the evolution of the settlement pattern (Alderdice, 1963). Placing emphasis on land use change is the approach used by Jameson for the neighbouring township of Caledon (Jameson, 1967). Both Albion and Caledon townships contain part of its Niagara Escarpment and rough moraine land and are major areas of Toronto's urban shadow. Additional theses dealing with these townships are by Patterson and Plewes on Albion and Brown and Davies on Caledon (Patterson, 1950, Plewes, 1967, Brown, 1951, Davies, 1963). A good example of a general geographical thesis is one on Esquesing Township by Revell (Revell, 1955). This thesis is a thorough study of the historical development of the township and its urban centres. Generally, these township theses are primarily descriptive, but they do provide a useful record for the given year when they were completed.

Other theses have dealt with urban fringe townships or areas. Five such theses are noted specifically because of their more conceptual, analytical approach. Putnam, in a general way, dealt with the Toronto-Hamilton axis of urbanization (Putnam, 1959);

[1] Includes the 24 western-most counties of Southern Ontario; Ontario County is the eastern-most county included.

TABLE 1

POPULATION GROWTH, 1941-1966

	Population[a] 1941	Population[a] 1966	Per Cent Growth 1941-1966
Ontario	3,787,655	6,960,870	83.6
Western Ontario[b]	2,530,476	4,963,666	96.2
Toronto to Stratford Corridor	254,565	674,142	164.8
Total Incorporated Cities[c]	134,679	411,290	205.3
Total Incorporated Towns and Villages	226,414	61,156	131.5
Total Townships	93,472	201,696	115.8
Individual Incorporated Cities			
Kitchener	35,657	93,255	161.3
Burlington	14,939	65,941	342.3
Oakville	4,115	52,793	1,187.8
Guelph	23,273	51,377	120.6
Brampton	6,020	36,264	505.0
Galt	15,346	33,491	112.3
Waterloo	9,025	29,889	232.2
Stratford	17,038	23,068	35.9
Preston	6,704	13,380	99.6
Georgetown	2,562	11,832	361.8
Individual Incorporated Towns and Villages			
Port Credit	2,160	8,475	286.4
Milton	1,964	6,601	231.0
Streetsville	709	5,884	742.8
Hespeler	3,058	5,381	74.2
St. Mary's	3,635	4,750	30.6
Acton	2,063	4,416	109.5
Fergus	2,832	4,376	57.2
Elmira	2,012	4,047	101.5
New Hamburg	1,402	2,438	71.3
Bolton	577	2,344	303.4
Bridgeport	Not inc.	2,111	-
Waterdown	910	1,935	113.8
Elora	1,247	1,644	31.8
Tavistock	1,066	1,294	21.4
Erin	499	1,195	139.5
Ayr	761	1,134	49.0
Milverton	1,015	1,122	10.5
Drayton	504	677	34.3
Caledon East	Not inc.	673	-
Wellesley	Not inc.	659	-
Individual Townships			
Easthope S.	1,292	1,721	33.2
Easthope N.	1,815	2,082	14.7
Mornington	2,423	2,596	7.1
Ellice	2,307	2,703	17.2
Downie	2,061	2,429	13.0
Blanshard	1,697	1,917	13.0
Waterloo	9,247	9,938	Major annex.
Wilmot	4,215	6,397	51.7
Wellesley	4,236	4,889	16.7
Woolwich	4,061	6,023	46.3
Dumfries N.	2,996	3,696	Major annex.
Puslinch	2,312	2,982	30.4
Guelph	3,984	2,307	Major annex.
Eramosa	2,287	3,190	39.1
Erin	2,605	3,430	30.8
Pilkington	1,035	1,288	24.4
Nichol	1,471	2,126	44.5
Garafraxa W.	1,382	1,555	14.3
Peel	2,713	3,087	14.8
Maryborough	2,028	2,084	2.7
Garafraxa E.	1,001	1,743	74.2
Burlington (Nelson)	4,169	Burlington City	-
Oakville (Trafalgar)	4,585	Oakville City	-
Nassagaweya	1,867	2,791	47.4
Esquesing	3,375	7,550	23.6
Toronto	12,481	93,492	648.0
Toronto Gore	801	1,268	58.2
Chinguacousy	3,716	16,281	340.6
Albion	2,039	3,572	26.1
Caledon	3,036	4,068	33.9
Flamboro E.	4,034	5,089	26.2
Urban areas with major annexations 1941-1966			
Kitchener-Waterloo-Bridgeport Preston-Hespeler-Waterloo Township	63,691	153,954	141.8
Galt-Dumfries N. Township	18,342	37,187	102.8
Guelph-Guelph Township	27,257	53,684	96.7
Burlington-Nelson Township	19,108	65,941	745.3
Oakville-Trafalgar Township	8,700	52,793	506.8

[a] Annexations have been ignored except for the urban areas included in the table.

[b] Western Ontario includes the 24 western-most counties of Southern Ontario; Ontario County is the eastern-most county included.

[c] Cities in this study are arbitrarily defined as places having 10,000 or more people in 1966.

Russwurm did a comparative study of the urban fringe using assessment roll data for three medium-sized western Ontario cities—Kitchener-Waterloo, London and Sarnia (Russwurm, 1961); Durst tackled the problem of land value increases in Waterloo Township (Durst, 1963); and Plewes and Tennant were concerned especially with the impact on the rural land and rural people (Plewes, 1967, Tennant, 1968). A number of other theses dealt with urban fringe townships but in a more descriptive way (Dean, 1949, Porter, 1950, Gardner, 1952, Forrester, 1953, Stanford, 1957, MacKenzie, 1958).

Another group of mainly descriptive theses exists for specific urban centres and these are listed in the bibliography. Among the more useful from an analytical standpoint are two on the regional role of Galt in the Grand River urban triangle (Sellner, 1969) and McKenzie's manufacturing base analysis of Galt (1966).

The theses noted above are primarily concerned with the locational sub-system of the urban system. Several other studies dealt with more specific locational elements of the urban system, such as recreational land or flood plain problems (Dobson, 1948, Barrett, 1958, Bell, 1963). Still others deal locationally with the historical geography of a municipality (Fraser, 1953, Spricenicks, 1961, Haldane, 1963).

Studies of the interactional sub-system are few in number. The most valuable of these deal with retail shopping flows. Two of these studies, while done in the study area, are of significance for their theoretical approach and findings.

Murdie compared quantitatively, travel differences between Mennonites and "modern" Canadians in the area north of Kitchener-Waterloo for a variety of goods (Murdie, 1965); and Hill, in a thorough quantitative analysis of a central place village, Elora, developed power indices to assess the attraction of different centres on Elora residents for various goods (Hill, 1969). His techniques are utilized later in this study when flows from peripheral villages are analyzed.

Other types of flows in the external spatial structure remain largely uninvestigated. Sellner and Riddell have used telephone flows (Riddell, 1965, Sellner, 1969) while Goheen and Whitfield have used newspaper circulation (Goheen, 1964, Whitfield, 1966). Fluid milk flows have been investigated for Toronto and Kitchener-Waterloo (Neal, 1962, Cooper, 1967). Only one descriptive study has looked at commuting flows (Dahms, 1962). Hence, despite the importance of flows in understanding urban systems, much remains to be done on the interactional sub-system. The reasons why became clear again in this study: the lack of available data, the cost in time and money of gathering the data directly.

Two other research sources have not been directly evaluated although they are of importance in the study area. The first is the various reports of M.T.A.R.T.S; the second is the work being done as part of the Waterloo Area Regional Government Study on which a report is to be completed for the Department of Municipal Affairs in 1969.

PART III

THE LAND SPACE MATRIX

In this descriptive and analytical part, and in those parts which follow, the outline for a spatial approach to urban systems given in Part I is generally followed. Thus, the locational sub-system elements are presented first, followed by the interactional sub-system elements. The main departure is the combining of the population and land space elements in this part.

The land space matrix consists of all the land outside the areas delimited as cities, towns and villages which are the organizing nodes set within their surrounding land space. To ensure strict comparability of change for areal units over time for the various variables used, the 1941 boundaries of incorporated places were made the same as those of 1966. The township survey lots were used for this adjustment. Where incorporated boundary changes by 1966 included only part of a township lot, the whole lot was included within the city or town limits. Because of this adjustment, the areas for 1966 of the cities and towns as defined in this study, are slightly larger than the actual incorporated area. Villages are defined using township survey lots.

Because untabulated raw data are used in this part of the study, many definitional decisions had to be made. These definitions are discussed next.

The Data Analysis Framework

Population Variables

Using the listed occupations of owners and tenants given in the township assessment rolls, families were classified as either farm or non-farm. Ambiguous occupations were classified according to the operational rules listed in Appendix A.

Land Use Variables

Some compilation difficulties exist in this sub-group of data variables. Generally, land use was divided into farm and non-farm, using the same occupation data used for the population categories. However, some non-farm population does live on farm land. Usually it is easy to tell from the assessed values whether or not the land is assessed as farm land and then to categorize it as farm land use. The major exceptions of land assessed at farm rates and being classified as non-farm land use, are the land ownership categories (See land ownership below) of open space land and other land. Under open space land is included Conservation Authority land which is assessed at farm rates and may indeed be in farm use. Such land was, however, classified as non-farm use. Under the other land category, some difficulties arose with land use for extractive purposes such as sand and gravel and quarry operations. Where evidence clearly indicated that extraction was going on, the land would be classified under other land ownership and would be classified as non-farm land use. Where extraction was not identified, such land would be classified under ownership as landholding and under land use as farm.

It is worth emphasising here and repeating later, that the four non-farm land ownership categories of residential, open space, landholding and other land are *not* automatically, though usually, classified as non-farm land use. The rules used are as follows: (1) Residential land is always non-farm land use and includes only parcels 10 acres or less in size. (2) Open space land is always non-farm land use. (3) Landholding is non-farm land use only if (a) the parcel of land is less than 10 acres in size and has no buildings on it and (b) if farm assessment could not clearly be established and if the property is less than 50 acres. This second possibility occurs only for rough and forested land and for land owned for extraction of sand, gravel and stone. (4) Other land is always non-farm land use. Understanding of these distinctions is essential because landholding accounts for the largest proportion of non-farm owned land, but much of it is still in farm use and is classified as such for land use purposes.

Finally, note that the term farm use ordinarily includes cropland, forest land, swampland and other unimproved land. Acreages and number of parcels in both farm and non-farm land use were recorded for each township survey lot.

Non-Farm Land Ownership Variables

The statement is repeated that land ownership and land use are definitely treated as separate measures of land space in this study even though they are interdependent.

The initial two-fold breakdown into farm and non-farm land ownership was directly done from the assessment roll information. Then the non-farm owned land was sub-divided into four categories, which are discussed separately below. Finally, two of the four categories, residential and landholding, were further sub-divided into resident, non-resident and vacant land.

Residential: All parcels of land, ten acres or less in size occupied by non-farm population, are classified as residential land.

Open Space: All parcels of land owned by Conservation Authorities, and all land owned and used for commercial and non-commercial recreation purposes, are classified as open space land. Included are such uses as golf courses, church and other institutional camps and summer cottage developments.

Landholding: This category includes all parcels of land whose owner is identified as non-farm by occupation. In addition, where the occupation distinction is not clear in the assessment rolls, it also includes owners resident outside the township or resident in an incorporated place within the township. Included is farm land owned by farming corporations with urban headquarters, farm land owned by religious orders, gentlemen farms where the owner is identifiable as non-farm by occupation, and land owned by mineral extraction firms or manufacturing firms but not yet being directly used for these purposes.

Other: This non-farm category is really a miscellaneous land ownership grouping. Both because of limited acreages and because of sometimes

sporadic distribution, it was not considered necessary analytically to separately deal with these miscellaneous cases. Four general types of land ownership occur in this miscellaneous category, namely commercial, industrial, institutional and utility.

For the four categories of non-farm ownership just outlined and for the two residency categories outlined below, both acreages and a number of parcels were recorded for each township survey lot.

Non-Farm Resident and Non-Resident Land

The two categories of non-farm land ownership, residential and landholding, were further sub-classified as either resident or non-resident. Non-resident parcels comprise those parcels within a township whose owner either lives in an incorporated urban place within the township or who lives outside the township; resident parcels then, are those whose owner lives within the township in which the parcel is located. Non-resident land ownership is considered to be an indicator of the spread of urban shadow as is the remaining category of land ownership, non-farm vacant land.

Non-Farm Vacant Land

This ownership category is defined to include parcels from the landholding category without building assessment. Like the non-farm, non-resident land ownership category, with which it is closely associated spatially, this category provides an additional measure of the spread of urban shadow. However, non-farm vacant land does include both resident and non-resident ownership.

Assessment Variables

Assessed values of land and total assessment to the nearest hundred dollars were recorded for both farm and non-farm land parcels. Note specifically that the farm and non-farm assessed values used refer to land use and not to land ownership. For example, a landholding parcel could be non-farm owned, but if over 10 acres in size, it would usually be in farm land use and would be so categorized for the assessment variables.

Identification and Aggregation of the Raw Data

The raw data as defined above, after a laborious compilation (see Appendix B on use of assessment rolls for analytical data), were key-punched on I.B.M. cards and later transferred to tape. The raw data have been identified at five levels of aggregation and can be retrieved at each of these levels with appropriate computer programming. The five types of aggregations from the most specific to the least specific are: survey lot, township block, Department of Highways Zone (where zones have been identified by The Department of Highways) township and county. Computer map plotting is also possible since both survey lots and township blocks have been identified using centroids by an 8-digit U.T.M. grid code.

The aggregation procedure was handled as follows. The raw data were copied from the assessment rolls by individual parcel. Data for the parcels were then aggregated to survey lots which are the basic unit for which data were stored (see Table 2). The survey lots (16,754 in total for the 31 townships when combined for 1941 and 1966), were then aggregated for analytical purposes into blocks averaging seven square miles in area. This aggregation reduced the data to manageable proportions for analysis with 334 blocks for 1966 and 308 blocks for 1941 when data were not available for Pilkington Township and were incomplete for Nassagaweya, Toronto Gore and Caledon Townships. Since blocks are contained within townships, data for townships were obtainable by aggregating block data.

Aggregation to Department of Highway Zones has to proceed from the survey lot level. As a rule, the highway zones are larger and much more irregular in size than the township blocks delineated in this study for analytical purposes, but aggregation of the data to the highway zone level will permit comparison of highways flow data with the land space data gathered from the assessment rolls. Such aggregation has not been achieved in this study because of time constraints and data comparability problems resulting from some incompatibility between the different area studies of the Department of Highways.

Delimitation of Township Blocks

Some comments on the delimitation of the basic analytical areal unit used in the land space analysis i.e. the township block, will be useful. A compromise was attempted between the statistical need to have areal units of nearly the same size and a meaningful division of land space. The following basic rules were used for delimitation:

1. Township boundaries were adhered to. This constraint was included because township units were used for some analytical purposes.

2. As far as possible, block sizes were kept between six and eight square miles—the statistical constraint. (The mean block size is seven square miles).

3. As far as possible, block boundaries were not to coincide with roads. This constraint is a meaningful one because urban developments are simultaneously associated with both sides of a road. Because of the township boundary constraint and the similar area constraint, it is impossible to always adhere to this rule.

4. As far as possible, where villages occur, a single block surrounds them. The reasoning behind this constraint is the same as for the third constraint, i.e. urban expansion proceeds outward from a village in all directions.

5. City and town boundaries were delimited for 1966 and the same boundaries were then used for 1941; thus, strict areal comparability is maintained for 1941 and 1966.

Finally, in the analysis of the block data, it is essential to keep in mind always that the unincorporated villages defined for separate analysis include, within their areal extent, all survey lots in which they are located. Hence, a village will usually be between one

TABLE 2

SUMMATION OF ASSESSMENT ROLL DATA BY SURVEY LOTS

				Column No.
(1)	Population numbers by lot	(a)	Farm	1 - 2
		(b)	Non-farm	3 - 5
(2)	No. of Parcels and Acreages by lot (3 columns for acres, 2 columns for parcels)			
	A.	By use		
		(a)	Farm acres, parcels	6 - 10
		(b)	Non-farm acres, parcels (where non-farm land farmed include land is farm land)	11 - 15
	B.	Residency (by owner)		
		(a)	Non-farm resident acres, parcels	16 - 20
		(b)	Non-farm non-resident acres, parcels	21 - 25
	C.	Non-farm Vacant (by owner)		
		(a)	Non-farm acres, parcels	26 - 30
	D.	By owner - Non-farm		
		(a)	residential acres, parcels	31 - 35
		(b)	recreational acres, parcels	36 - 40
		(c)	landholdings acres, parcels	41 - 45
		(d)	other acres, parcels	46 - 50
(3)	Assessment by lot (by use) (3 columns for total, 3 columns for land)			
		(a)	Farm Total/Land	51 - 56
		(b)	Non-Farm Total/Land	57 - 62
(4)	Identification			
			Department of Highway Traffic Zones	63 - 65
	01 - 09		County	66
	20 - 39		Township	67 - 68
	40 - 69		Block	69 - 70
	01 - 99		Lot	71 - 72
			UTM grid	73 - 80

and two square miles in area and the typical crossroads village will consist of four survey lots. This subtraction of land space provides a constant area for the unincorporated villages for which population totals were tabulated from the assessment rolls for 1941 and 1966. Note that no other population source is available for unincorporated villages in 1941. For the land space analysis, this subtraction means some reduction in the intensity of the measures used to examine the spread of urbanization, because usually urbanization phenomena occur more frequently adjacent to the villages. By this definition, such urban phenomena are thus included within the village, including of course some farm land, and consequently measures of expanding urbanization will be somewhat more conservative than they would be without this method of village separation.

Levels of Land Space Analysis

In this study, the use of land space for man's activities has been generalized into three levels. One of the levels involves intense use of land space in a nodal form, which can be referred to as urban use, that is, the cities and towns or the urban nodes. The second level is that identified as villages which still have a nodal form but where land is not really used at an urban density. The third level is the land space use which provides the location space matrix within which the intense nodes of urban use, the cities and towns and the nodes of the villages are imbedded. This third level includes about 95 per cent of the total area and in 1966 was still 90 per cent in farm use. This level is identified as the land space matrix.

The analysis of the spread of urbanization effects across the land space matrix 1941-1966 is the major contribution of this study. Nowhere previously has such a detailed study of the cross-sectional slices of urban expansion for two time periods been presented. The factor analytic approach used provides summary results of the data variables, taken either directly from the assessment rolls or derived by further manipulation from the data taken directly from the assessment rolls. The normal caveat, of course, holds: The results must be interpreted only according to the data variables available for analysis.

Expanding Urbanization And The Land Space Matrix: A Cartographic Analysis Approach

The spatial variation by township block of selected data variables considered to be indicators of expanding urbanization is first presented using basically cartographic analysis. Then, using factor analytic methods, the simultaneous variation and interdependencies of all 58 data variables recorded are presented.

Selected Measures of Expanding Urbanization

Of the 58 variables used for the factor analysis of land space, 46 were derived from the assessment roll data and provide measures of population, land use, non-farm land ownership, and assessment. The remaining 12 are spatial measures derived from map measurement. Table 5 provides a complete listing of the 58 variables.

On the basis of previous theoretical and empirical work, six variables were selected to outline the expansion of urbanization cartographically in the Toronto to Stratford Corridor Area 1941 and 1966. These variables are discussed in the following paragraphs with appropriate overview comments about their effect in the study area.

The Variables Selected for Cartographic Analysis

Population Non-Farm: The per cent of the township block population classified as non-farm is expected to decline with distance from urban centres and with distance from major roads (Philbrick, 1961). A number of studies have also used non-farm population as a measure of the extent of the urban fringe (Russwurm 1961, 1964). Usually these studies note that urban fringe areas have over 50 per cent of their non-nodal population classified as non-farm. In the study area, excluding city, town, and village populations, the population was 54 per cent non-farm in 1966. Here the term urban fringe is used without specific spatial delineation for the areas surrounding the urban nodes—the areas undergoing the most noticeable urban expansion. In the factor analysis, an urban fringe factor is derived, which includes residential land and non-farm population as basic variables. The term "urban fringe" is preferred over the other commonly used term "rural-urban fringe" because the process which culminates in the conversion of land from rural to urban use is generated in the urban node.

Total Population Density: This variable is used as a complementary absolute measure to the relative non-farm population percentage measure of expanding urbanization. The same distance decline hypothesis holds as for per cent of population non-farm; indeed the distance decline hypothesis holds for most urbanization phenomena (Berry and Schwind, 1968). From 1941 to 1966, increasing population density is almost completely attributable to non-farm population increases. Meanwhile, farm population has remained constant at a mean value of about 20 persons per square mile though the farm population has declined from approximately 45,000 to approximately 39,000. The concomitant result for farm land acreages with farm population densities remaining constant has to be a loss of farm land. Approximately 300 square miles of land in farm use in 1941 had been converted to non-farm land use by 1966; farm use acreages have declined from approximately 2,300 square miles to approximately 2,000 square miles. Any increase in population density is thus largely attributable to the increase in non-farm population. For the land space matrix, the non-farm population increased from approximately 7,000 in 1941 to approximately 45,000 in 1966. Again note that these totals exclude the population of the 73 villages separately delimited, nor does it include the population of Bramalea in 1966, for the block containing Bramalea was excluded because of its urban complexity.

Four population density categories were mapped and were designated as rural (less than 25 per square mile); semi-rural (25 to 49 per square mile); semi-urban (50 to 119 per square mile); and urban (greater than 119 per square mile). These densities were developed from the per acre densities which had been calculated to two decimals. The rural category approximately represents the mean farm land use density of 20 per square mile with the addition of minimal non-farm population or the total population density in 1941. The semi-rural density range has an upper limit density of 49 people per square mile and approximately represents a category boundary where at least half the population is non-farm. The upper limit of the semi-urban category (50 to 119

people per square mile) once the mean farm density of 19 per square mile is subtracted out, then represents a non-farm density of approximately 100 people per square mile. Using a family mean of four people, this density range would represent approximately 25 urban residences per square mile at the upper limit of 119 people per square mile and approximately eight urban residences at the lower limit of 50 people per square mile. Similarly then, the category over 119 per square mile designated urban, means that more than 25 urban residences are present per square mile or one resident parcel for every 25 acres on the average.

Non-Farm Land Use: This variable was also mapped for 1941 and 1966 by township block. While non-farm land use generally declines with distance from urban places and major roads, the pattern noted in this study is more complex because in this study, open space land is included under non-farm land use. Since much of the open space land is Conservation Authority land, it is, of course, located in or adjacent to river valley areas suited for such development and often its location bears little direct link to the urban places.

Non-Farm Residential and Land Holding Ownership: A relative and an absolute measure of expanding urbanization were selected from the non-farm land ownership variables. The relative measure is the per cent of total land in the landholding category; this measure is a good indicator of the extent of urban shadow effects or urban corridor effects. The term "urban shadow" is used for those areas subject to pressure to remove the land from agricultural use (Hind-Smith, 1961). The absolute measure used as a selected complementary indicator is the acres of residential land which is a significant indicator of the extent of the urban fringe. Non-farm residences are probably the most visible phenomena of expanding urbanization, though not a large user of land since residential land in the study area ordinarily accounts for about one-sixth of the non-farm use or less than three per cent of the total land space matrix in 1966. Landholding, on the other hand, is the major category of non-farm land ownership accounting for about two-thirds of the non-farm owned land or approximately 16 per cent of the total land. Much of this land, however, remains in farm land use.

Standard Deviation of Farm Assessment Per Acre: The final variable selected for cartographic analysis is the standard deviation of farm land assessment per acre. The use of this variable is an attempt to use assessment values. Since assessment practices are not comparable from township to township or over time, standard deviations were calculated by township and mapped. The use of this technique provides a comparable relative measure instead of the non-comparable raw assessment data. The hypothesis involved in selecting this variable is that farm assessment nearer urban places is higher because the land component is assessed at higher rates in expectation of conversion to urban use (Hind-Smith, 1964, Russwurm, 1967). Simultaneously, however, a second hypothesis has to be recognized; namely, that farm assessment should be higher in areas of better quality land.

The Cartographic Analysis

A brief note on incomplete data is inserted here. For 1941, assessment rolls were not available for Pilkington Township and were incomplete for Nassagaweya, Toronto

Gore, and Caledon Townships. For 1966, data for the block containing Bramalea east of Brampton (Block 54), was not compiled because of the amount of data involved. Estimates based on field checks are used for the cartographic analysis.

Per Cent Population Non-Farm: Figure 2 provides clear evidence that urban expansion had not really begun in the Stratford to Toronto Corridor in 1941. It does, however, show that already the blocks with the higher percentages of non-farm population were mostly associated with the area south of Highway 7 and especially with the environs of Kitchener-Waterloo and Galt.

TABLE 3

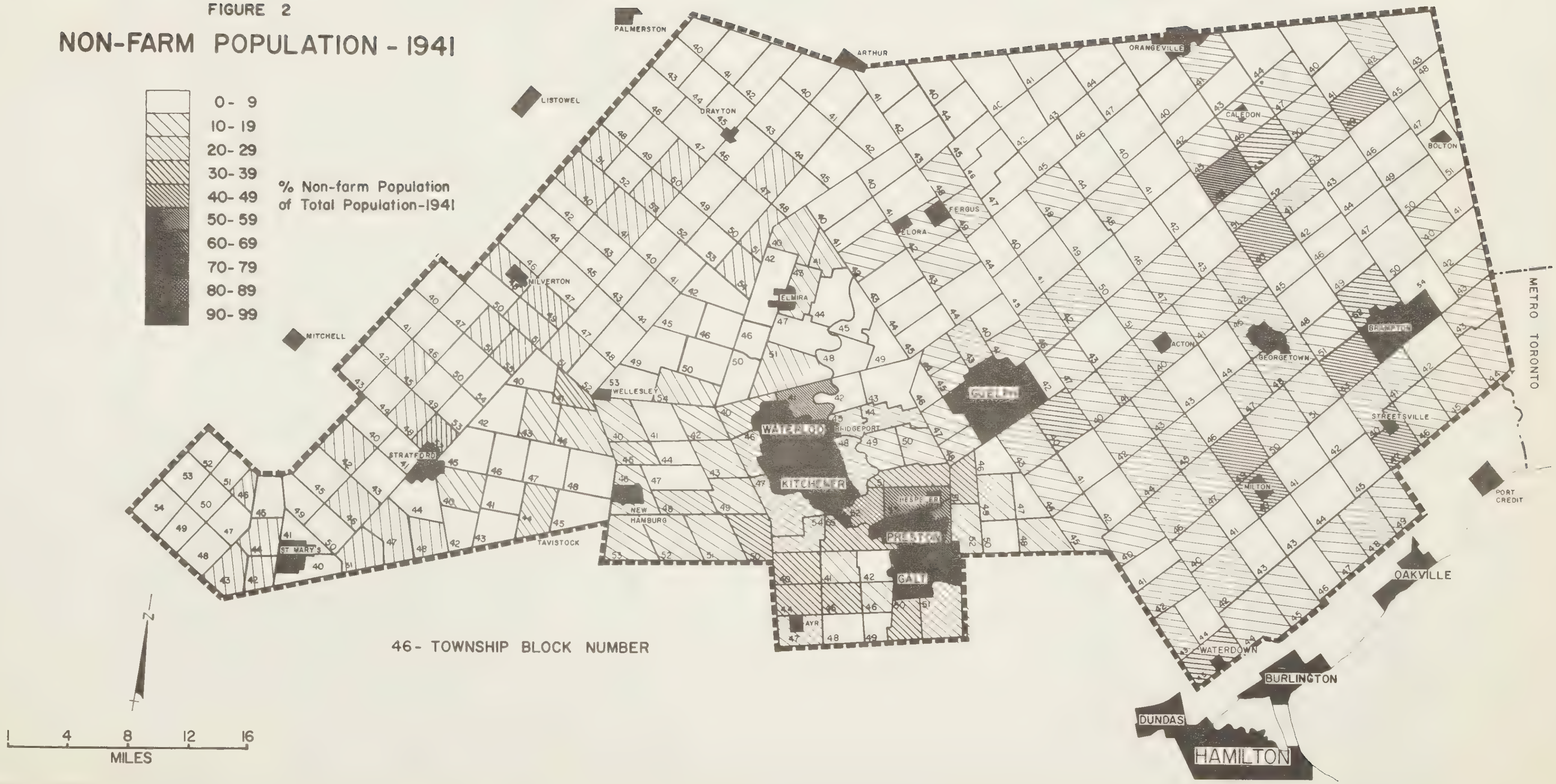
DISTRIBUTION OF POPULATION NON-FARM BY TOWNSHIP BLOCKS

Per Cent	Number of Blocks		
	1941	1966	1941-1966
0- 9	185	60	91
10-19	89	53	47
20-29	36	25	44
30-39	14	33	44
40-49	7	34	30
50-59	1	31	42
60-69	2	33	21
70-79	1	35	13
80-89	0	19	3
90-100	0	12	0
	335	335	335

The distributions of the non-farm population percentages are illustrated by Table 3. My research in the London to Hamilton area (Russwurm, 1964) indicated that, as expanding urbanization occurred over an area, the non-farm population distribution when tabulated for small areal units, would be a strongly, positively skewed distribution when the area was still predominantly rural. As urbanization progressed, the distribution would change to a normal distribution and then in the later stage of more or less continuous urban development, the distribution would become strongly, negatively skewed. Evidently, the Stratford to Toronto corridor area was mainly rural in 1941, as the population densities indicated, and is now at an intermediate stage of urban expansion though distribution is still somewhat positively skewed. However, by 1966 only 34 per cent of the blocks had less than 20 per cent non-farm population as compared with 82 per cent of such blocks in 1941. Looked at another way, the mean non-farm population per cent per block rose to 40 per cent in 1966 from 11 per cent in 1941. (For the total study area, the comparable percentages were 54 for 1966 and 14 for 1941, showing the effect of skewness.) It is worth noting again that the Stratford to Toronto Corridor area was delimited so as to extend well beyond the core corridor area; that is, if similar statistics were prepared only for the basic corridor area, the figures would be considerably higher.

FIGURE 2

NON-FARM POPULATION - 1941



Source: Compiled from Township Assessment Rolls - L. H. Russwurm

As already evidenced by higher percentages in 1941, the high concentration of non-farm population in 1966 is still in the Kitchener-Waterloo area and south of Highway 7. In addition, the increasingly strong influence of Metro Toronto by 1966 is noted in the eastern part of the study area. So too is the noticeable domination of non-farm population in the blocks which include the Niagara Escarpment (Location Map, Figure 1, for comparison). Of the 22 township blocks including parts of the Niagara Escarpment, 17 of them were over 60 per cent non-farm in population in 1966. Such results support previous findings (Hind-Smith, 1964, Russwurm, 1961) which indicate that rougher, more scenic land is more subject to early non-farm development when accessible to dwellers of urban areas.

The rapid drop-off in non-farm population percentages (see Figure 3) north of Guelph and west of Kitchener-Waterloo, provides a cartographic measure of the extent of the urban corridor in 1966. A suggested delimitation of the extent of the urban fringe would be the inclusion of contiguous blocks that are 70 per cent or more non-farm in population.

The spatial cross connections with the London to Hamilton urban corridor, as noted in an earlier study (Russwurm, 1964), are again seen in the high non-farm population percentages for the area south of Galt and adjacent to Burlington. It is in the Galt-Brantford-Hamilton triangle that the Stratford to Toronto and London to Hamilton corridors fuse.

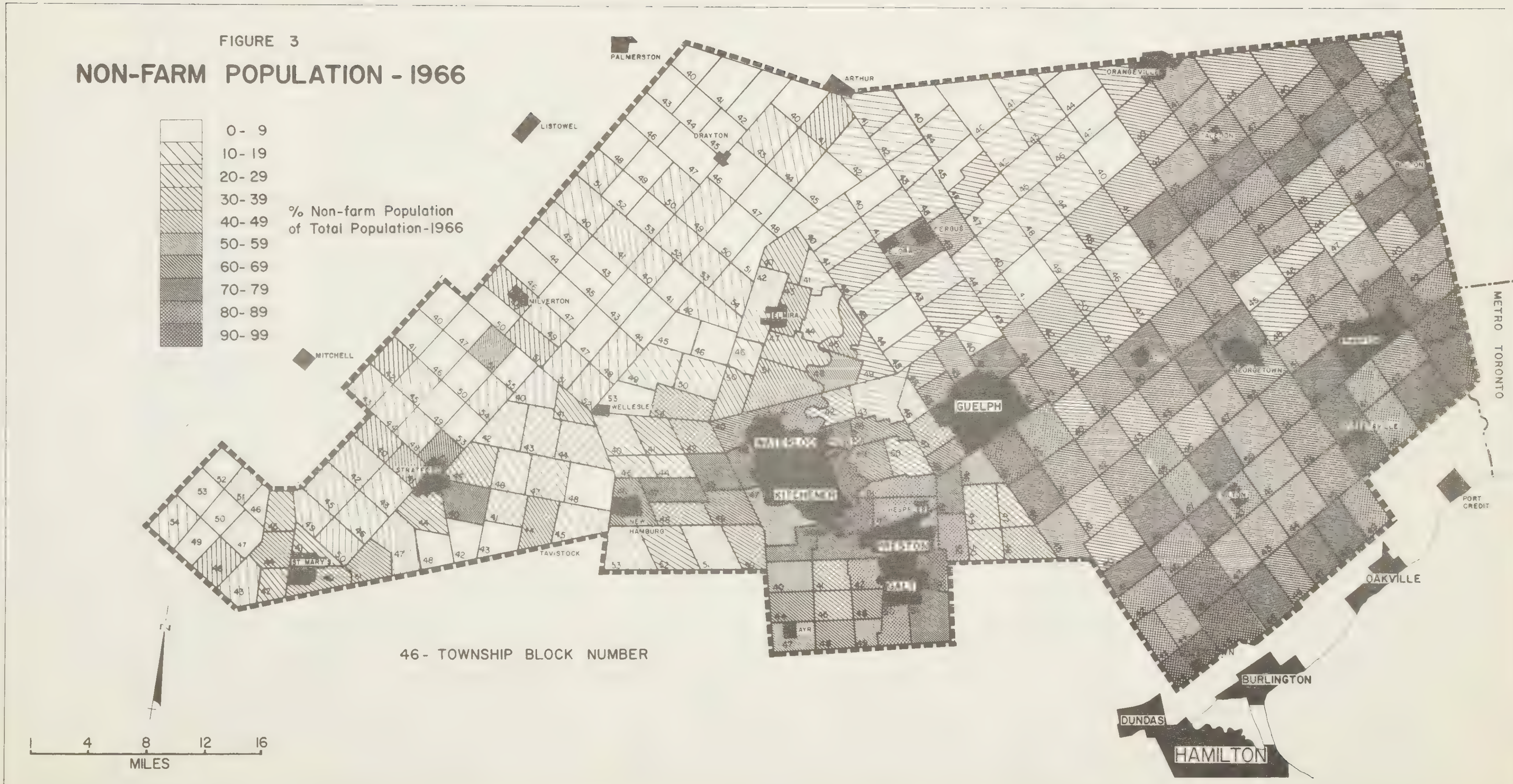
Further support for the above noted spatial patterns can be seen in Figure 4 which shows the actual percentage point increase in non-farm population by blocks (1941 per cent subtracted from 1966 per cent). A simple breakdown of the change distribution 1941-1966 given in Table 3 shows that the positive skewness was maintained with 54 per cent (182) of the blocks increasing less than 30 percentage points. Thus, based on the selected indicator of per cent population non-farm, the Stratford to Toronto corridor area is still in an intermediate stage of urban expansion.

Total Population Density: This selected variable was not included among the variables used in the factor analysis. At the time, the reasoning for non-inclusion was that farm population densities for the farm land use area and non-farm population densities for the non-farm land use would account for population density. As a check later, the total population density was mapped by township blocks and revealed a very distinct spatial pattern closely associated with the cities and by 1966 with the highway network, especially the corridor highways. Of the variables used, it appears to be the best single indicator of the extent of the urban fringe. A check of Figure 6, the population density for 1966 shows that a minimum population density of 50 people per square mile outlines the major areas of urban fringe clearly. The lower densities for lots 42, 44 and 45 between Brampton and Toronto are the result of the land used by Toronto International Airport.

Based on the population density categories previously outlined, it is evident that the study area was almost completely rural in 1941 (see Figure 5). Note that the area of semi-rural densities north and west of Kitchener-Waterloo is the major area of Mennonite farms (Murdie, 1961). The higher densities are the result of the Mennonite farmers with their characteristically larger families. Note also that the merging

FIGURE 3

NON-FARM POPULATION - 1966



Source: Compiled from Township Assessment Rolls - L. H. Russwurm

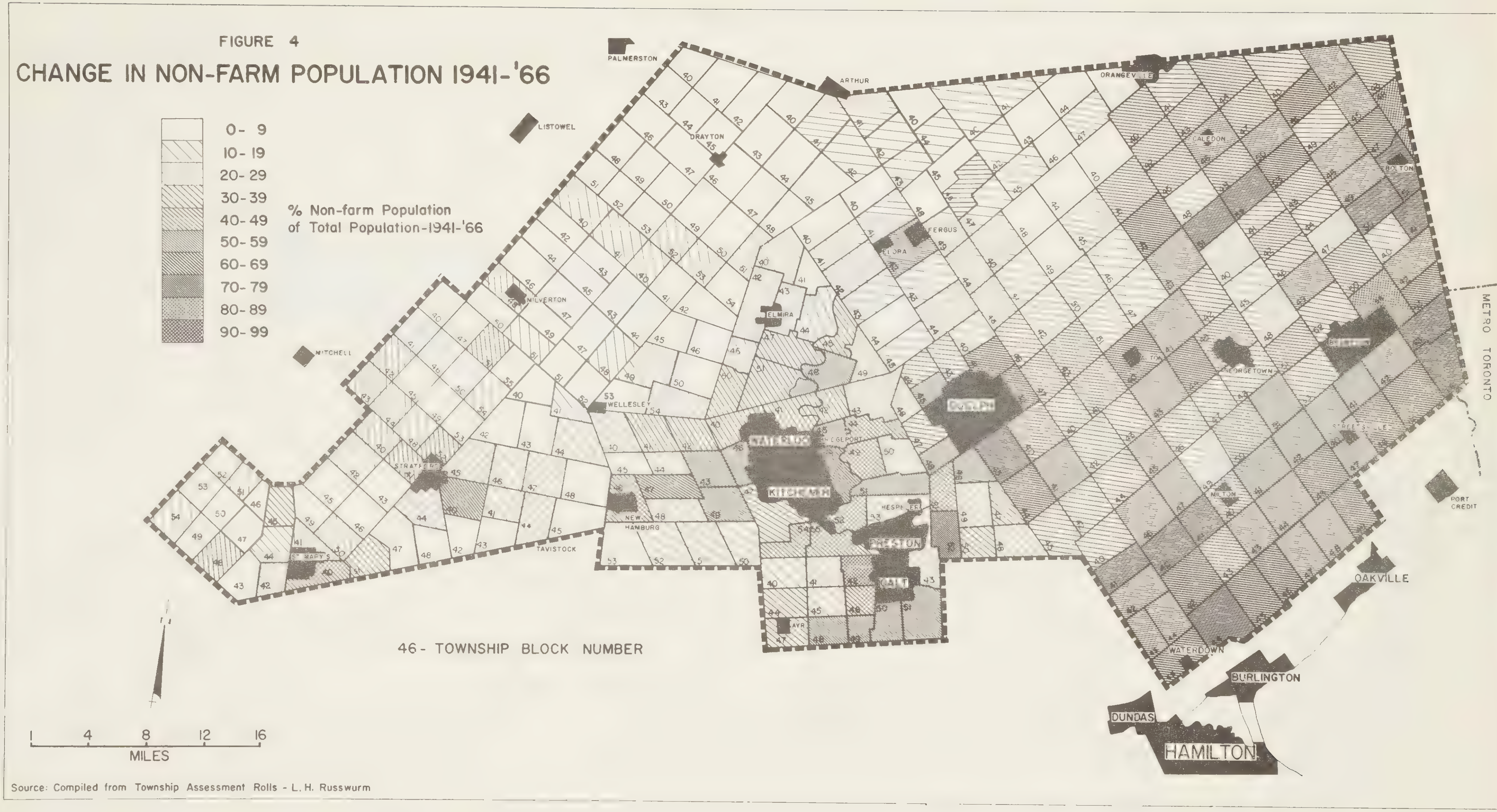


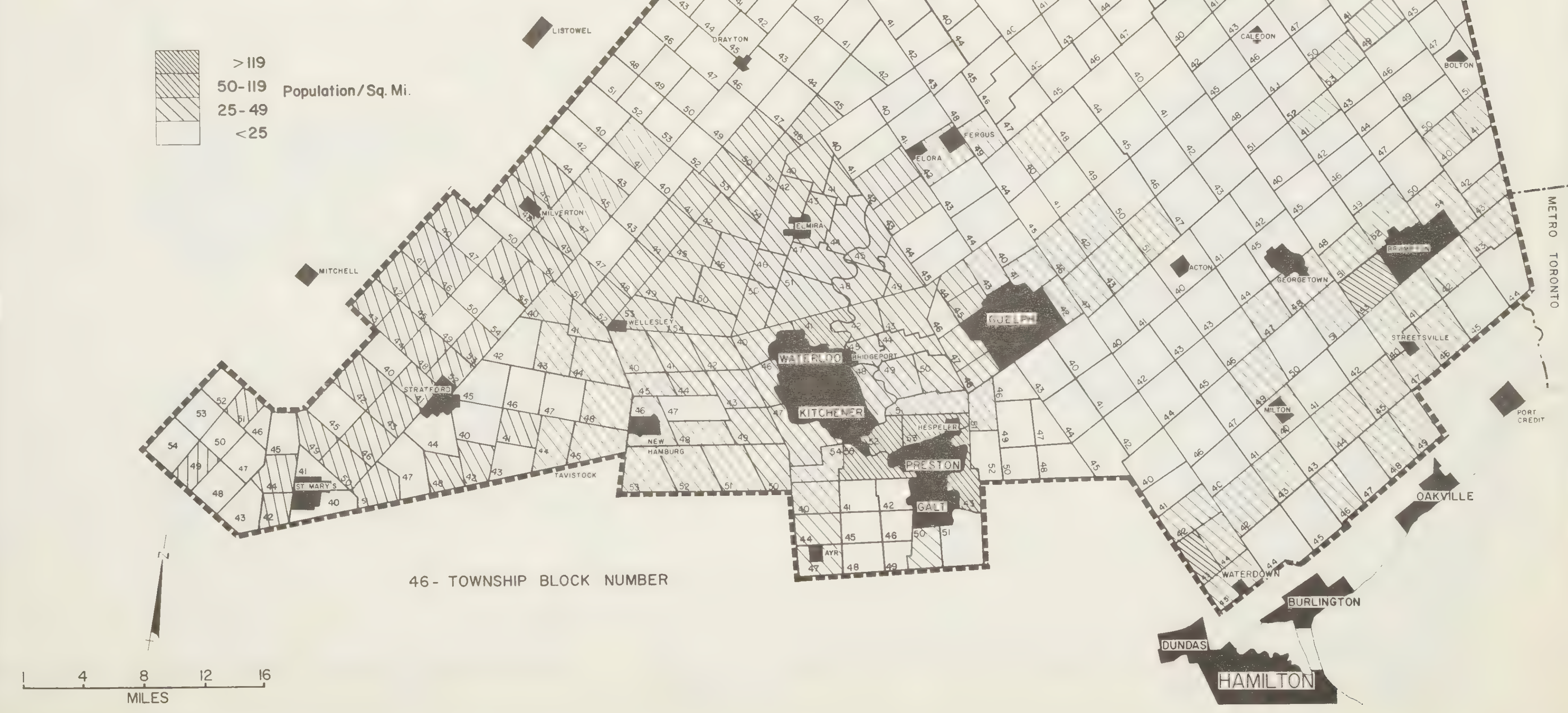
FIGURE 4

CHANGE IN NON-FARM POPULATION 1941-'66

Source: Compiled from Township Assessment Rolls - L. H. Russwurm

FIGURE 5

TOTAL POPULATION DENSITY - 1941



Source: Compiled from Township Assessment Rolls - L. H. Russwurm

influences for the area between Kitchener and Preston were already evident in semi-urban population densities of 1941.

By 1966 (Figure 6), several things stand out in the spatial pattern of population density. The expansion of the semi-urban category used to define the urban fringe is clearly seen in the Grand River Triangle area. The expansion has now surrounded Guelph, Galt, Preston and Kitchener-Waterloo. As well, a continuous extension has linked Elmira, Kitchener-Waterloo and New Hamburg. In the eastern part of the urban corridor, semi-urban blocks surround Burlington and extend north to Highway 401. A continuous urban fringe has also developed between Acton, Georgetown, Milton, Brampton, Streetsville and Metro Toronto. Except for one block which surrounds the village of Rockwood and one block west of Guelph, the urban fringe is continuous along Highway 7 from New Hamburg to Metro Toronto, and three outlying nodes of urban fringe occur around Stratford, Bolton and Fergus-Elora.

Most of the spatial patterns noted above for 1966 were present in an incipient form in 1941. For example, six of seven blocks with semi-urban densities in 1941 had urban densities by 1966 with only three other blocks reaching urban densities by 1966. Also the stability of the semi-rural densities in the Mennonite farming area north and west of Kitchener-Waterloo is maintained. So too is the rural density of the northern and extreme western part of the study area, which evidently lies outside the urban corridor. Finally, the rural density area occurring in 1941 south of and between Guelph and Georgetown, is still largely semi-rural in density in 1966. Such stable emerging population density patterns, suggest that simulation of the pattern would be possible, (see Morrill, 1965 A) although not attempted in this study.

Non-Farm Land Use: In 1941 all but 20 blocks had less than six per cent of their area in land use identified from the assessment rolls as being non-farm. In fact, 220 of the 335 blocks had less than one per cent of their land use in the non-farm category (see Table 4). For the block average, only 59 acres or 1.4 per cent of the land was in non-farm use—the same percentage as recorded for the total area. This percentage is derived approximately equally from the four non-farm land ownership categories; residential, open space, landholding and other.

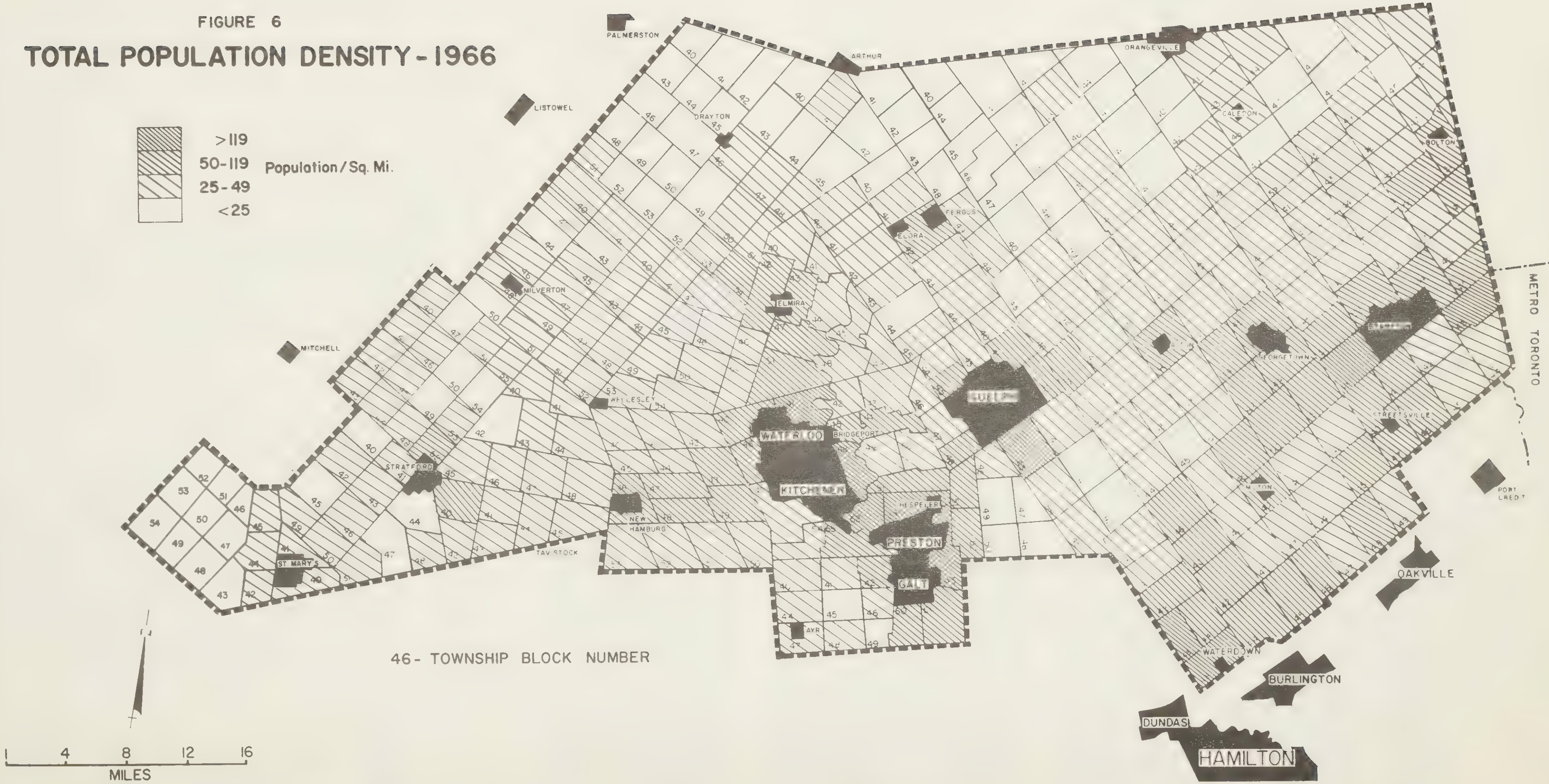
TABLE 4

DISTRIBUTION OF NON-FARM LAND USE BY TOWNSHIP BLOCKS

	Number of Blocks		
Per Cent	1941	1966	1941-1966
< 1	220	86	105
1- 5	94	78	72
6- 9	18	46	52
10-19	1	75	67
20-29	1	29	25
30-39	1	13	8
40-49	0	6	4
50-60	0	1	2
> 60	0	1	0
	335	335	335

FIGURE 6

TOTAL POPULATION DENSITY - 1966



Source: Compiled from Township Assessment Rolls - L H Russwurm

Once again the spatial pattern on Figure 7 reveals the base from which the 1966 pattern would develop; that is, non-farm land uses are expected to decline regularly in two ways: outward from the cities and perpendicular to the highways (Philbrick, 1961). Thus, the Grand River Triangle stands out as having a more or less continuous block of land one to five per cent in non-farm use; the Niagara Escarpment can be traced, and so can several other areas of hilly terrain, e.g. west of Waterloo and from Bolton to Orangeville. The two higher percentage isolated blocks are the Belwood Lake block north of Guelph and Toronto International Airport.

The fleshing out of the incipient spatial pattern of 1941 can be noted for 1966 on Figure 8. The spatial pattern already noted for non-farm population percentages and population density are generally repeated again. However, the two variables of non-farm population and non-farm land use, though significantly (99 per cent level) intercorrelated using the township blocks as areal units, have only 46 per cent of their joint variance explained ($r = 0.68$). Still, the increase in non-farm use can be particularly noted in the Grand River Triangle, south of Highway 7, east of Guelph and in Peel County (Figure 9). The rapid decline of this selected measure of urbanization north of Highway 7 is generally evident except in Caledon and Albion townships east of Highway 10—an area where the Toronto-Stratford and Toronto-Barrie Corridors probably fuse. Again, the map evidence supports a division of the study area into a corridor of expanding urbanization and a rural area bordering it. Reference to Table 4 reveals that over half of the blocks (177 of 335) showed percentage point increases of five per cent or less from 1941 to 1966 indicating two things: (1) the inclusion of rural areas outside the basic urban corridor; (2) the intermediate stage of urban expansion of the study area.

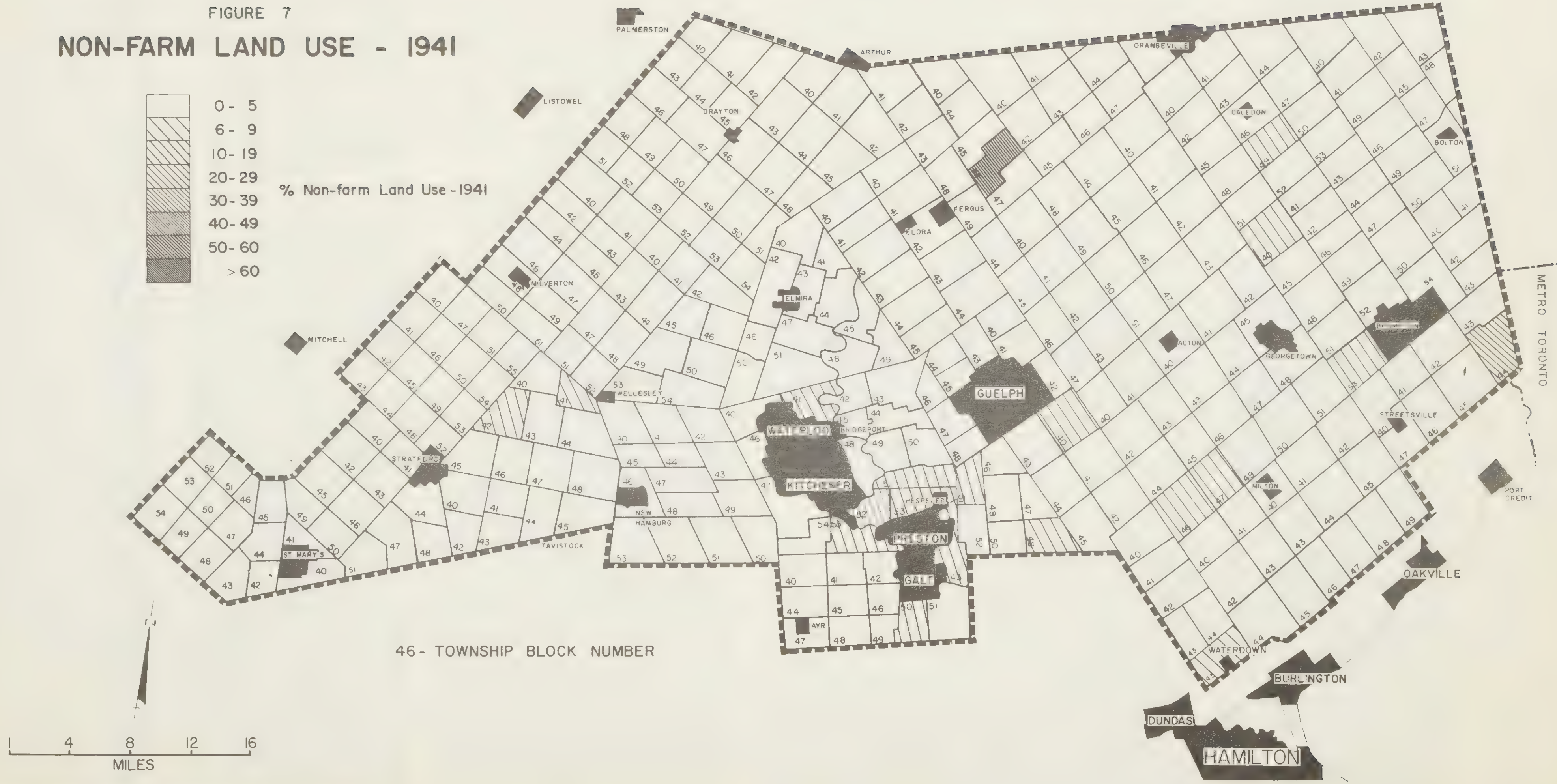
A brief explanation of several of the higher percentage isolated occurrences of non-farm land use in 1966 is pertinent (Figure 8). In the St. Mary's area, the operations of the cement company and the Wildwood Reservoir stand out. In the north, the open space land of Conestogo Lake and Belwood Lake occur. The higher percentages in the Kitchener-Waterloo-Preston-Galt axis include Conservation Authority land, gravel pit operations, residential and landholding developments. Northeast of Burlington are four blocks with over 30 per cent of their area in non-farm land use. These blocks include Escarpment land in open space and quarrying operations, as well as the Mohawk Raceway. Adjoining Metro Toronto are the airport block and the Clairville Conservation area and in the Bolton area are Conservation Authority holdings, especially on the Humber Valley.

Non-Farm Residential Acreage: The absolute acreages in residential ownership were mapped to establish the spatial patterns of urban residences. Such residences are probably the most noticeable phenomena of urban expansion across the land space matrix. By 1966, the block mean was 28 residential parcels on 58 acres, giving a block mean of just over two acres per residential parcel. Comparable figures for 1941 were five residential parcels and 11 acres indicating stability in the size of residential parcels. By definition, residential parcels are 10 acres or less in size; parcels of occupied land greater than 10 acres in size are included under landholding.

The correlation profiles of residential acreage per cent and landholding ownership are presented in Table 4. Later, multiple regression models are developed for these and

FIGURE 7

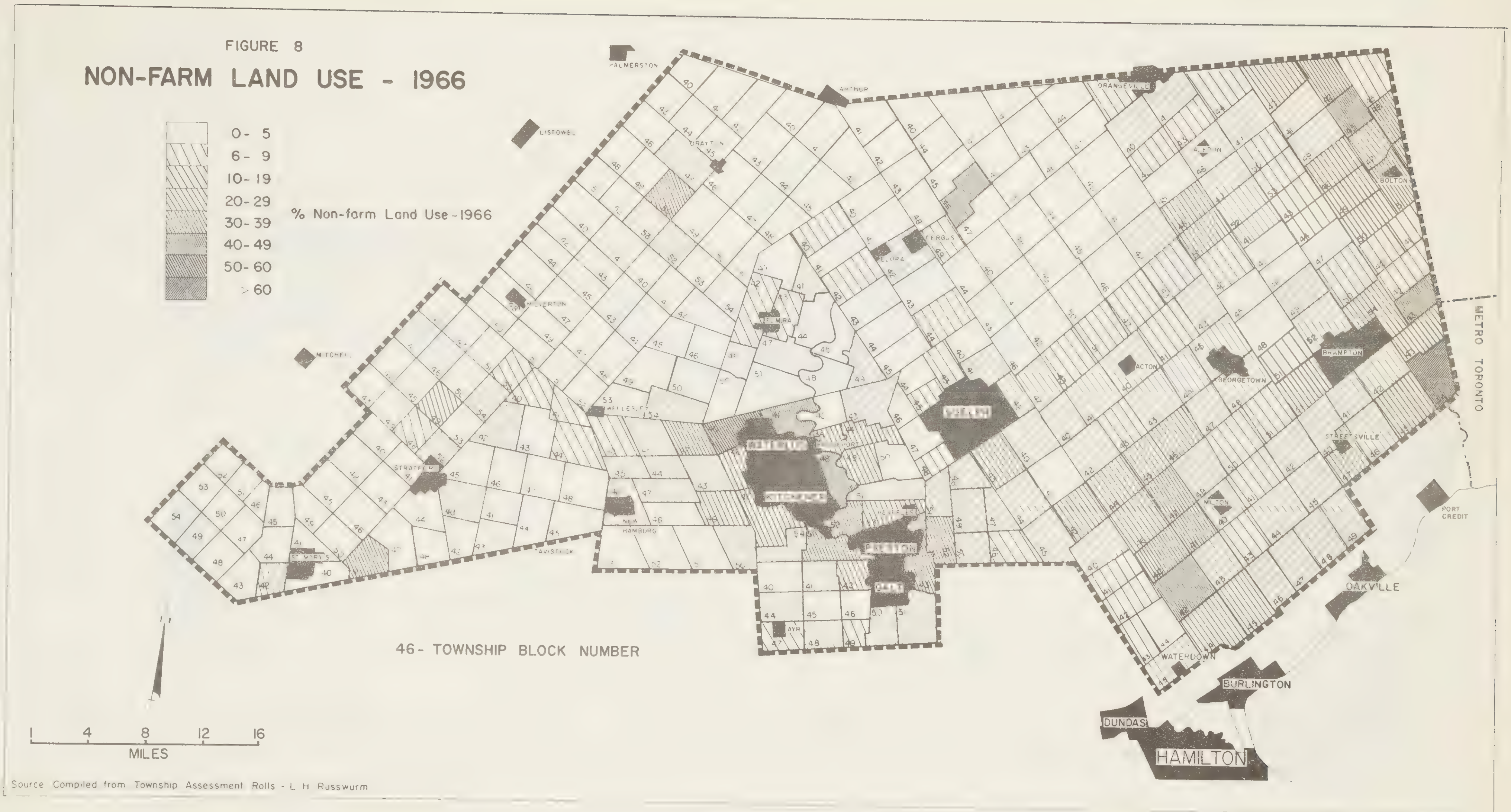
NON-FARM LAND USE - 1941



Source Compiled from Township Assessment Rolls - L. H. Russwurm

FIGURE 8

NON-FARM LAND USE - 1966



Source Compiled from Township Assessment Rolls - L H Russwurm

FIGURE 9

CHANGE IN NON-FARM LAND USE-1941-'66

Source. Compiled from Township Assessment Rolls - L H Russwurm

some other variables thought to be especially important in analysing the expansion of urbanization across land space. Here, the relationship of residential acreage and other variables is analysed briefly. As expected from empirical knowledge, residential acreage is most highly correlated with numbers of non-farm population (0.80), with the number of non-farm land use parcels (0.75), with residential parcels (0.81) and with the per cent residential of total land (0.96). Ten other variables correlate over 0.50 with residential acreage. One variable correlates negatively over –0.50. That variable is the per cent farm land assessment is of total assessment, suggesting that non-farm residential acreage occurs in a limited amount where farm land assessment is most important, i.e. in the most rural blocks.

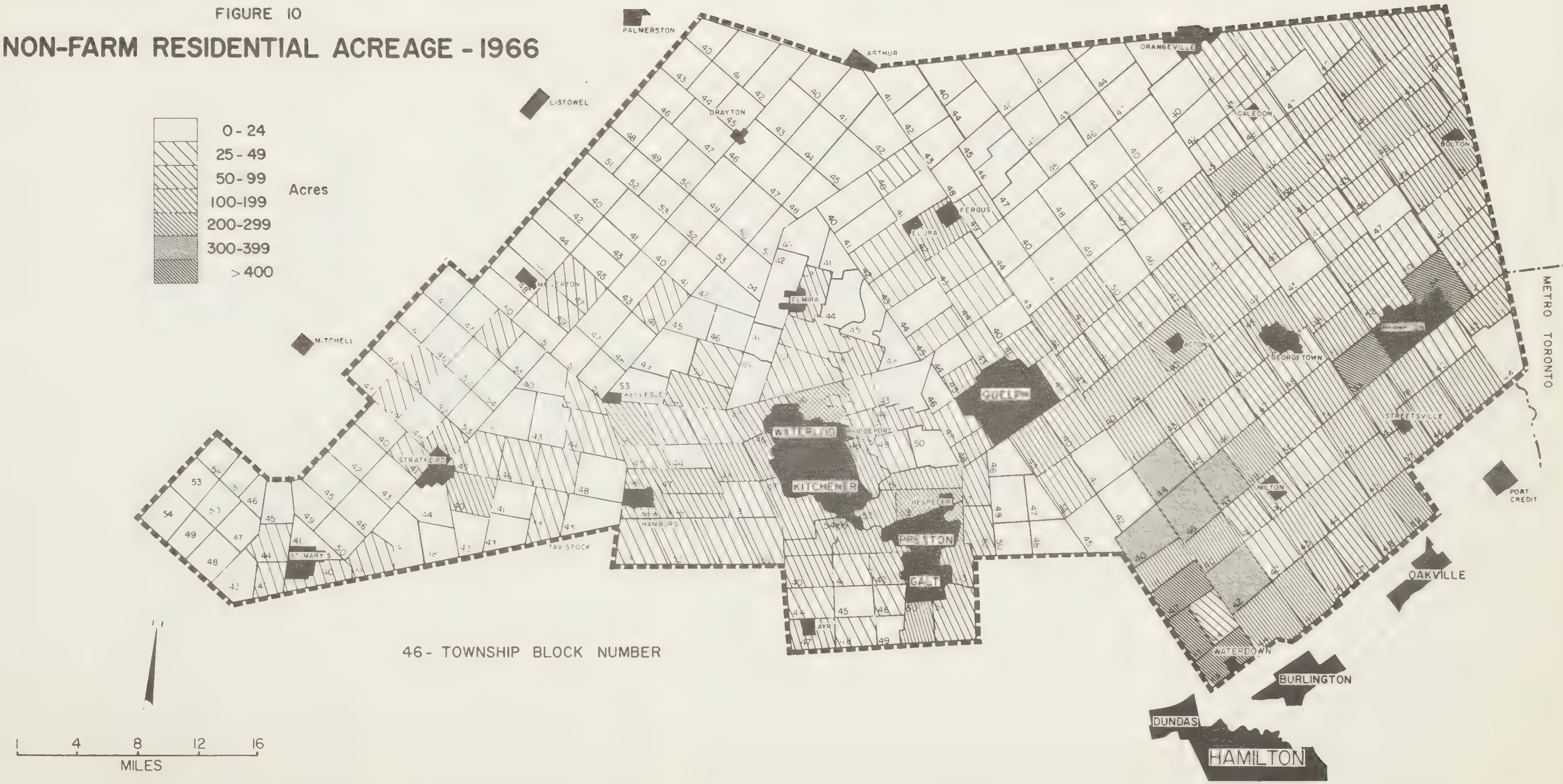
The map of residential acreages for 1966, Figure 10, shows the now familiar spatial pattern of highest intensity in the Grand River Triangle, south of Highway 7 (Acton to Georgetown to Brampton) and east of Highway 10 (see Location Map, Figure 1 for highways). The limited residential acreages north and west of Kitchener-Waterloo and Guelph are evident for this variable as they have been for other variables. It is north of the basic urban corridor that most of the 277 blocks with fewer than 25 residential acres occur. As will be noted later, the spatial pattern correlates well with the urban fringe—urban corridor factor derived from the factor analysis. Attention is drawn to two particular variations in the residential acreage pattern: one is the large acreage of residential land in the backslope area of the Niagara Escarpment between Burlington and Highway 401 where eight of the 10 blocks having more than 300 acres in residential acreage occur; the other is the zone of blocks having mostly less than 50 acres of residential land occurring between Kitchener-Waterloo-Galt-Preston and Guelph. Using the locational element of residential acreage, this evidence suggests that proper regional planning could still prevent the urban merging of the Grand River Triangle cities. Needless to say, major urban developments such as an industrial basin and a satellite town, will create pressures for urban merging in this area.

Non-Farm Landholding Ownership: This relative measure of the per cent of total land in landholding ownership is one of the most important variables for measuring the expansion of urbanization across land space. It is a conservative indicator of land speculation over large areas of land space; it is a conservative indicator because only direct ownership by non-farm people is identified. Land held under option to buy cannot be identified from the assessment rolls. It is, however, only a crude indicator of areas of land speculation; rather it has been deliberately labelled landholding because many of the acres included in this category of ownership may be just that—landholding with no real intent to re-sell for speculative profit.

This variable is also a major variable loading highly on the urban shadow factor identified from the factor analyses. Further, according to block means, it accounts for 65 per cent of the non-farm owned land in 1966 per block or 16 per cent of the total land owned per block. I emphasize here that figures quoted for block means are based on all the blocks for the study area and thus would be higher if only the blocks included in the now approximately delineated urban corridor were used. That the urban expansion across land space is a stable and identifiable process over time is indicated by the fact that comparative figures for per cent of land in landholding in 1941 were respectively 58 and four per cent. Hence, though the per cent of total land

FIGURE 10

NON-FARM RESIDENTIAL ACREAGE - 1966



46 - TOWNSHIP BLOCK NUMBER

Source Compiled from Township Assessment Rolls - L. H. Russwurm

in landholding has increased considerably (4 to 16 per cent) using block means, the proportion of the non-farm owned land in landholding has increased only slightly (58 to 65 per cent).

The correlation profile for 1966, given in Table 5, reveals that the per cent of total land in landholding ownership is correlated with 16 variables with a value higher than 0.50 or –0.50. The two variables negatively correlated are farm population and farm land assessment as a per cent of total assessment. Thus, blocks with high farm land assessment and high numbers of farm population, have less landholding. Such a relationship fits previous findings (Russwurm, 1964). Per cent of the total land in landholding ownership is especially associated with the several variables measuring non-resident and vacant land. Also, the high correlations with total non-farm owned acres (0.88) and with per cent non-farm owned land of total land (0.93), reflects the fact that landholding accounts for about two-thirds of the non-farm owned land. All the variables in Table 4 are later tested in a multiple regression model with per cent land holding as the dependent variable; it is then that the question of intercorrelation of variables is looked at.

Turning briefly to the cartographic representation of this variable, it is noted from Figures 11 to 13, that the basic spatial pattern of higher intensity of occurrence south of Highway 7 and roughly east of a zone from Guelph to Orangeville again exists. For 1941, four variations are however worth noting: one is the extension north of Guelph to Arthur of slightly higher landholding ownership (one to five per cent); the second is the lack of landholding ownership in the Mennonite farming area north of Kitchener-Waterloo; the third is the tongue of blocks between and north of Georgetown and Brampton having less than one per cent in landholding; the fourth is the tier of blocks south of Orangeville in the Niagara Escarpment area with generally 10 to 19 per cent of the land in landholding. Here then is the initial core of landholding development in the Niagara Escarpment area.

The same four variations continue to exist in 1966 (Figure 12) with some minor changes. The extension north of Guelph has only intensified in an area southwest of Arthur towards Conestoga Lake. Further field work would be needed to find out reasons for this variation; it may be that lower farm land prices are permitting non-farm purchases for summer residences, combining easy access to the Grand River Triangle cities and to both Conestoga and Belwood Lakes. Landholding percentages in this area are still relatively low, however, being mostly in the 10 to 19 per cent category. The Mennonite area north of Kitchener-Waterloo and the Georgetown-Brampton tongue, continue to have low percentages of landholding. The blocks south of Orangeville have continued to intensify in landholding, expanding towards Bolton; most blocks are between 40 to 60 per cent in landholding.

From the map of per cent change, 1941 to 1966, three additional areas of intensification in landholding are noted. One is the area surrounding Kitchener-Waterloo-Preston-Galt; another is the area southeast of Guelph between the Niagara Escarpment and Burlington; the third is an area west of Metro Toronto from Brampton to Streetsville to Oakville. The first and the third areas probably represent primarily land speculation in anticipation of future built-up urban fringe development. The area southeast of Guelph probably represents a combination of anticipated

TABLE 5

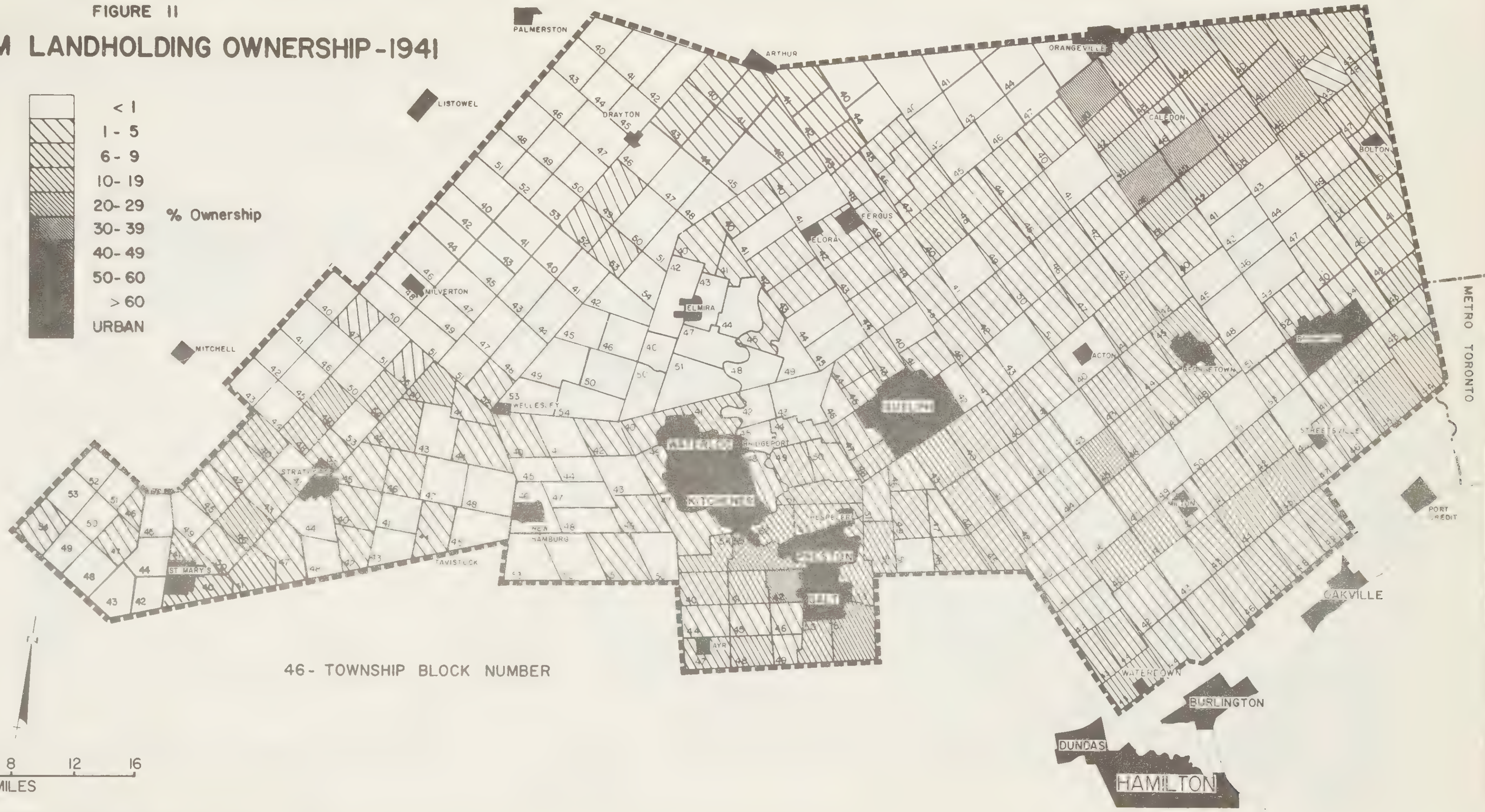
VARIABLES CORRELATING HIGHLY WITH EITHER RESIDENTIAL ACREAGE OR PER CENT LANDHOLDING OWNERSHIP, 1966

Variable Number	Variable	Correlation[a]	
		Residential	Landholding
1	Population - per cent non-farm	0.69	0.75
2	Population - farm	−0.06	−0.51
3	Population - non-farm	0.80	0.49
6	Population - per cent lots with some non-farm	0.67	0.64
9	Land use - per cent non-farm	0.53	0.56
13	Land use - non-farm parcels	0.75	0.47
16	Non-farm land ownership - non-resident parcels	0.62	0.72
17	Non-farm land ownership - vacant parcels	0.63	0.64
22	Non-farm land ownership - residential parcels	0.81	0.39
24	Non-farm land ownership - landholding parcels	0.66	0.76
26	Non-farm land ownership - non-resident acres	0.46	0.83
27	Non-farm land ownership - vacant acres	0.39	0.74
28	Non-farm land ownership - residential acres	1.00	0.48
30	Non-farm land ownership - landholding acres	0.51	0.95
32	Non-farm land ownership - total non-farm acres	0.57	0.88
33	Non-farm land ownership - per cent non-resident of total land	0.45	0.89
34	Non-farm land ownership - per cent vacant of total land	0.38	0.82
35	Non-farm land ownership - per cent residential of total land	0.96	0.53
37	Non-farm land ownership - per cent landholding of total land	0.48	1.00
39	Non-farm land ownership - per cent non-farm of total land	0.53	0.93
40	Assessment - per cent farm land of total	−0.64	−0.50
41	Assessment - per cent non-farm of total	0.69	0.60
42	Assessment - per cent non-farm land of total	0.44	0.50

[a] Includes all variables for which either residential or landholding correlates > 0.50; all correlations are significant at the 99 per cent level.

FIGURE 11

NON-FARM LANDHOLDING OWNERSHIP-1941



Source Compiled from Township Assessment Rolls - L H Russwurm

FIGURE 12

NON-FARM LANDHOLDING OWNERSHIP-1966

Source Compiled from Township Assessment Rolls - L. H. Russwurm

FIGURE 13·

CHANGE IN NON-FARM LANDHOLDING OWNERSHIP-1941-'66

Source Compiled from Township Assessment Rolls - L. H. Russwurm

built-up urban fringe development (directly south of Guelph and north of Burlington) and country living by urbanites on the scenic back slope areas of the Niagara Escarpment.

Standard Deviation Farm Assessment Per Acre: As noted earlier, the use of this basic statistical parameter of a distribution permits the use of assessment data. Nevertheless, as in the rest of the cartographic analysis, mainly a descriptive and not a fully explanatory analysis is possible. Understanding of the processes at work which have resulted in the spatial patterns mapped will demand much more detailed investigation than is possible in this research project. In the case of farm assessment per acre, the higher assessment resulting from better quality land would have to be controlled before the urban shadow hypothesis (Hind-Smith, 1964) that farm assessment increases near a city as farm land becomes of greater potential for conversion to urban uses could be verified. In the present descriptive analysis of the spatial pattern, revealed in Figures 14 and 15, higher assessment for better quality land and higher assessment because of urban shadow effects are intertwined. However, data on land capability at the detailed level needed, is becoming available through the Department of Soil Science, University of Guelph and in a future analysis, the conflicting hypothesis of higher assessment for better quality land may perhaps be controlled.

Since the study area in 1941 was primarily rural throughout, the map of standard deviation in farm assessment per acre should reveal areas of better quality land. Such a statement depends on two underlying assumptions. First, the farm assessment consists of both land and building assessment. Thus, the assumption is that building assessment is approximately the same per acre across the study area. A check of the raw assessment data during compilation suggests that this assumption is reasonably acceptable in 1941 but less so in 1966. Second, it must be assumed that the township assessors do, in fact, assess better quality land at higher rates.

What do the spatial patterns reveal for 1941 (Figure 14)? The data are mapped using categories of one standard deviation. Given the technique and its calculation on a township base, the result will be that approximately half of the blocks in a township will be above the mean and half will be below. Despite this constraint, the map still makes empirical sense. For instance, blocks including the Niagara Escarpment and its backslope area, are primarily below the mean. The area of good farmland associated with till and clay plains from Milton to Bolton stands out with positive deviations and so does the area surrounding Guelph with its extension to the northeast. Further positive deviations over a continuous area occur around Kitchener-Waterloo to Elmira and northwards; here the possibility of higher building assessment occurs because this area includes much of the Mennonite farming area. Detailed investigation of topographic, physiographic and soils maps would be necessary for more specific explanatory comments; my cursory checks of such maps suggests that such explanation would be possible in combination with field checks.

As has been the case with most of the 1941 maps, Figure 14 reveals mainly a pre-urban expansion pattern. As such, however, it provides a static spatial control against which the urban expansion pattern of 1966 can be compared.

FIGURE 14

STANDARD DEVIATION - 1941 FARMLAND ASSESSMENT PER ACRE

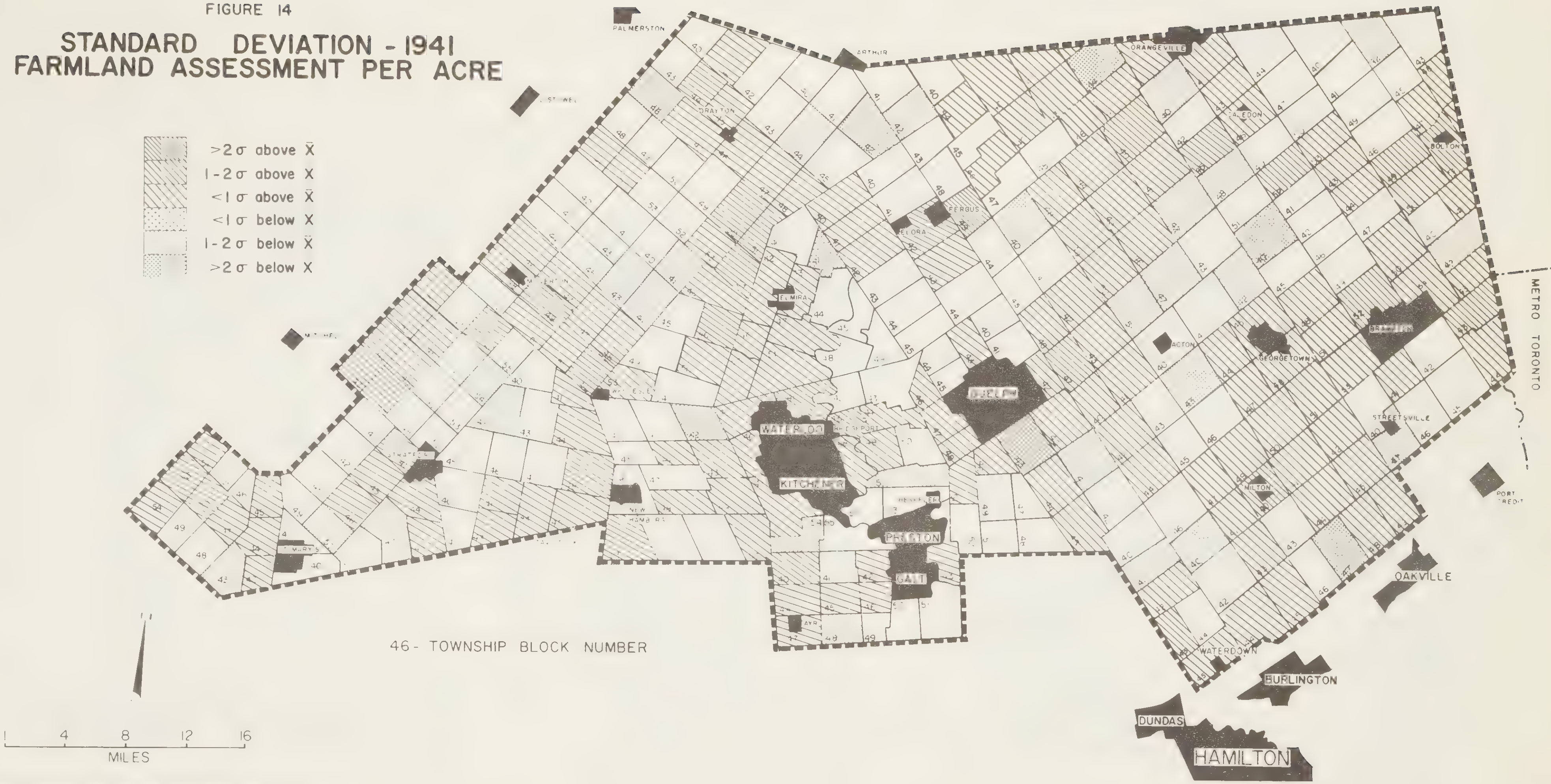


FIGURE 15

STANDARD DEVIATION - 1966
FARMLAND ASSESSMENT PER ACRE

compiled from Township Assessment

Whatever the causes, the 1966 spatial patterns are more complex (Figure 15). Using the 1941 patterns as a control, several areas provide some indication of urban shadow assessment. Most evident are the increased number of blocks with positive standard deviations greater than one adjoining Stratford, Kitchener-Waterloo, Galt, Guelph and Brampton. The much more irregular pattern around the cities generally suggests that the urban shadow effects occur. In checking out the coefficient of variation (standard deviation divided by the mean) for 1941 and 1966 by township an increased coefficient occurred for 21 of the 31 townships. I interpret these increases as another indication of the effects of urban expansion and as partial verification that urban influences do effect farm assessment.

Several other spatial variations are noted from Figure 15. The Milton-Bolton zone of positive deviations still exists as does much of the Guelph area pointed out for its positive deviations in 1941. While changes have occurred in the Kitchener-Waterloo area since 1941, the block of positive deviations identifying the Mennonite farming area around Elmira is evident. Finally, the Niagara Escarpment is less clearly identified as a zone of negative deviations, suggesting that urban shadow assessment effects are occurring there.

Summary of the Cartographic Analysis

Three points are reiterated. (1) The 1941 spatial patterns for the variables analysed indicate first, that the 1941 patterns are a good control for comparison because they indicate pre-urban expansion spatial patterns; second, that the incipient core areas of the major variations in the 1966 spatial patterns can already be identified. (2) While a precise attempt to delimit the northern boundary of the urban corridor is not made, the maps of the selected variables measuring urban expansion clearly suggest the feasibility of such delimitation. The southern boundary was previously pre-defined by my earlier study (Russwurm, 1964). (3) The six selected variables subjected to cartographic analysis reinforce each other satisfactorily as complementary measures of urban expansion. These variables will be further tested in a multiple regression model of the urban corridor system.

Expanding Urbanization And The Land Space Matrix: A Factor Analysis Approach

The second half of this analysis of the land space matrix utilizes the multivariate statistical method of factor analysis. This method handles interdependencies between large numbers of variables and collapses them into a smaller number of factors consisting of clusters of interrelated variables. The basic text providing the mathematical background on this technique is that of Harmon (Harmon, 1967). Two excellent brief explanations of the method and its use in geographical research are those given by Hodge and Murdie (Hodge, 1966, Murdie, 1969).

The Variables

Three separate factor analyses were undertaken on the variables. Cross-sectional analyses were completed for 1941 and 1966 using the identical 58 variables; thus, the factor structures for the two years could be readily compared. The third factor analysis

was a longitudinal one on the change in the variables 1941-1966. For this analysis only 43 variables were used. All the spatial variables were deleted since most of them had no change or very little change. In addition, the last three assessment variables (variables 44, 45, 46) were also deleted from the longitudinal analysis because of problems in interpreting what their change meant. These three assessment variables also did not load highly on any of the factors for 1941 or 1966 and thus contributed very little to the overall explanation of variance.

Since this analysis of the land space matrix is dependent on variables derived from the township assessment rolls for small areal units, the township block, the variables used in the factor analysis are largely dependent on the data available from the assessment rolls. Of the 58 variables used in the factor analysis (see Table 6), 46 are derived from the assessment rolls. The remaining 12 variables are spatial measures taken from maps. The variables are a mix of percentage and absolute data, mostly measured on interval and ratio scales. They are listed in Table 6 and are briefly discussed according to the basic categories of population, land use, non-farm land ownership, assessment, and spatial.

The Population Variables

Six variables were derived based on the division of population into farm and non-farm (Table 6). The per cent population non-farm and the per cent lots with some non-farm population provide measures of the relative importance and spread of population as the critical human element in expanding urbanization. The absolute numbers of farm and non-farm population are included because many blocks had no non-farm or very little non-farm population in 1941. Thus, since the farm population has remained relatively constant, a small absolute increase in non-farm people could mean a large per cent increase.

The population density measures were derived for farm and non-farm land use. It was expected that non-farm population density per acre of non-farm land use would increase near urban nodes and would be correlated with land use and land ownership variables. However, non-farm population densities, based only on non-farm land use, turned out to have a very complicated pattern due at least partly to the inclusion of open space and other land. For example, for 1966, the highest correlations of non-farm population densities with other variables were all below 0.50 with the highest r values being −0.37, 0.36, and 0.45 (significant at the one per cent level). These variables, respectively, are the average size of non-farm land use parcels, the per cent residential acres of non-farm owned land and the standard score of non-farm assessment per acre. These relationships do make sense: i.e., the larger the average size of the non-farm land use parcel, the lesser the density; the greater the per cent of non-farm land ownership in residential land, the greater the density; and the greater the standard score of non-farm assessment, the greater the density. This standard score relationship means that the more the non-farm assessment per acre is above the mean non-farm assessment for a given township, the greater is the non-farm population density.

The farm population density measure was included as a complementary measure to farm population. Since the township blocks are of similar size, farm population and farm density should increase together ($r = 0.74$ in 1966). The reasons for including

TABLE 6

LAND SPACE MATRIX VARIABLES USED IN THE FACTOR ANALYSES

A. Six Population Variables

1. Population - per cent non-farm
2. Population - farm
3. Population - non-farm
4. Population - farm density per acre
5. Population - non-farm density per acre
6. Population - per cent lots with some non-farm

B. Seven Land Use Variables

7. Land use - farm acres
8. Land use - non-farm acres
9. Land use - per cent non-farm
10. Land use - average size of farm parcels in acres
11. Land use - average size of non-farm parcels in acres
12. Land use - farm parcels
13. Land use - non-farm parcels

C. Twenty-six Non-Farm Land Ownership Variables

14. Non-farm land ownership - per cent non-resident acres of non-farm land
15. Non-farm land ownership - per cent vacant acres of non-farm land
16. Non-farm land ownership - non-resident parcels
17. Non-farm land ownership - vacant parcels
18. Non-farm land ownership - per cent residential of non-farm land
19. Non-farm land ownership - per cent open space of non-farm land
20. Non-farm land ownership - per cent landholding of non-farm land
21. Non-farm land ownership - per cent other of non-farm land
22. Non-farm land ownership - residential parcels
23. Non-farm land ownership - open space parcels
24. Non-farm land ownership - landholding parcels
25. Non-farm land ownership - other parcels
26. Non-farm land ownership - non-resident acres
27. Non-farm land ownership - vacant acres
28. Non-farm land ownership - residential acres
29. Non-farm land ownership - open space acres
30. Non-farm land ownership - landholding acres
31. Non-farm land ownership - other acres
32. Non-farm land ownership - total non-farm acres
33. Non-farm land ownership - per cent non-resident of total land
34. Non-farm land ownership - per cent vacant of total land
35. Non-farm land ownership - per cent residential of total land
36. Non-farm land ownership - per cent open space of total land
37. Non-farm land ownership - per cent landholding of total land
38. Non-farm land ownership - per cent other of total land
39. Non-farm land ownership - per cent non-farm of total land

D. Seven Assessment Variables

40. Assessment - per cent farm land of total
41. Assessment - per cent non-farm of total
42. Assessment - per cent non-farm land of total
43. Assessment - per cent farm land of farm
44. Assessment - per cent non-farm land of non-farm
45. Assessment - standard score of farm per acre
46. Assessment - standard score of non-farm per acre

E. Twelve Spatial Variables

47. Spatial - distance to nearest of Toronto or Kitchener-Waterloo
48. Spatial - distance to nearest place - a city
49. Spatial - distance to nearest place - a town
50. Spatial - distance to nearest place - a village
51. Spatial - distance to corridor highway
52. Spatial - miles of east-west highway
53. Spatial - miles of north-south highway
54. Spatial - miles of east-west county road
55. Spatial - miles of north-south county road
56. Spatial - highway junctions
57. Spatial - highway and county road junctions
58. Spatial - county road junctions

farm variables at all in an urbanization analysis relate to the following somewhat contradictory hypotheses. (1) Farm land use, because of higher land values near urban nodes, should be more intense; therefore, farm population densities should be higher—the basic Von Thunen Theory (Grotewold, 1959, Chisholm, 1962). (2) But because of the imminent conversion of farm land to urban uses in the innermost parts of the urban fringe, a zone of less intensive farmland use and lower farm population densities may occur (Russwurm, 1964, 1967, Sinclair, 1967). Both the farm population and the farm population density loaded negatively with the *urban shadow* factor in 1966, indicating more support for the second hypothesis; that is, the greater the urban shadow, the lesser the farm population and farm population density. Support for the first hypothesis would demand that these variables load positively on the *urban fringe* factor which they did not.

The Land Use Variables

Acres, parcels and average size of parcels, were included for both farm and non-farm land use. The seventh variable is the per cent that non-farm land use is of total land. With one exception, the variables are not highly correlated with each other and thus appear to be useful independent measures of land use. The only pair highly intercorrelated for 1941, 1966, and change 1941-1966 (r = respectively, 0.98, 0.94, 0.95), is per cent non-farm land use and non-farm acres. One of these variables could, therefore, be deleted from the analysis with limited loss of information.

Land use variables, like the other variables related to expanding urbanization, are expected to show density declines outward from urban centres and perpendicular to major transportation routes linking urban centres. Since land use, identified as non-farm (urban, here) implies a further stage of urban development than does non-farm land ownership, variables measuring land use should be related more to the urban fringe than the urban shadow areas. This hypothesis is borne out in the factor analysis.

Non-Farm Land Ownership Variables

It is this category of variables for which the greatest amount of useful data can be extracted from the assessment rolls. Altogether, 26 variables were derived and thus, non-farm land ownership variables tend to dominate the factor analysis, even though a few of the variables are redundant.

As noted earlier, six types of non-farm land ownership are classified, with the basic classes, residential, open space, landholding and other, being mutually exclusive. These basic classes were defined and discussed in some detail earlier in Part III. The two residency variables—non-farm non-resident and non-farm vacant land are sub-classes of residential-landholding, and landholding, respectively; the residential and landholding classes as defined previously, can be resident or non-resident. Non-farm non-resident land ownership is considered to be a significant measure of expanding urban influence (see Plewes, 1967). Similarly, it is hypothesized that the number of vacant parcels increases with expanding urban influence as parcels are separated from larger parcels. As the urban influence increases, the absolute number of vacant parcels increases because people often purchase land some time in advance of building. Support for this

hypothesis is given in a study of Toronto Gore Township (Tennant, 1968). Also, for the study area as a whole, the number of non-farm vacant parcels has increased approximately seven-fold since 1941 to over 4,000 such parcels or over one-fifth of all non-farm land ownership parcels.

For each of the six classes of non-farm land ownership, four measures were used: acres, parcels, per cent of non-farm owned land, and per cent of total land. The remaining two non-farm land ownership variables are acres of total non-farm owned land and the per cent that total non-farm owned land is of total land.

Some redundancies exist in the non-farm land ownership measures. Because this is a "first" quantitative analysis of assessment roll data on land space, it was deemed advisable to enter absolute and relative variables. However, the absolute measure of acres could be deleted for all six classes of non-farm land ownership and for total non-farm owned land because correlations between acres and per cent of total land accounted for by each of the six classes and total non-farm owned land, were usually greater than 0.90 for 1941, 1966 and for change 1941-66. All remaining five pairs of variables with correlations greater than 0.90 involve landholding. Landholding acres are highly intercorrelated with non-resident and total non-farm acres; landholding parcels are highly intercorrelated with non-resident and vacant parcels; and landholding and total non-farm owned land as percentages of total land are also highly intercorrelated. These high intercorrelations result because four-fifths of the total acreage of the non-farm owned land is in the landholding class. For future work involving this classification of non-farm owned land, acreage measures can, therefore, be excluded as being redundant measures.

Assessment Variables

Seven relative measures of assessment were derived for this category. Four are non-farm assessment measures and three are farm assessment measures. Relative measures only could be used because assessment practices vary from township to township as well as between 1966 and 1941. All assessment data are based on land use and not land ownership.

In selecting the assessment variables, comparisons of non-farm and farm to total assessment and of land as a component of farm and non-farm assessment were kept in mind. Clearly, non-farm assessment increases with expanding urbanization. For the land space matrix, it normally accounted for 30 to 60 per cent of a township's total assessment in 1966, as compared with only five to ten per cent in 1941. In comparing farm and non-farm land assessment with total farm and non-farm assessment, the hypothesis being tested was that by 1966 land assessment has risen proportionally more than building assessment. The reasoning here is that with increasing urbanization land becomes more valuable—the basic land economics tenet. Also, for non-farm land, the increasing amount of open space, other, and vacant land should contribute to increased assessment of non-farm land as a proportion of total non-farm assessment.

For the study area, this hypothesis was not borne out for farm land. The countervailing force here, no doubt, was the increased capitalization of farm buildings in a livestock-dairying farm economy. In 1941, farm land by township usually accounted

for two-thirds to three-quarters of the total farm assessment; by 1966, this proportion was usually around one-half; nor is much evidence forthcoming at a finer spatial mesh—that of the township block, because a check of township blocks bordering cities also did not support the hypothesis. If the hypothesis has any validity, it will, therefore, have to come from a parcel by parcel check.

Nor is the hypothesis strongly borne out for non-farm land assessment. Generally, non-farm land as a proportion of total non-farm land, has declined from about one-third to about one-fifth. However, at the township level, seven of 27 townships with comparative data for 1941 and 1966, did show an increased proportion for non-farm land assessment. Three of the townships (Downie, Wilmot, Toronto) border cities; three other townships (Albion, Caledon, Esquesing) are crossed by the Niagara Escarpment; the seventh township (Maryborough) is the site of a major Conservation Authority development—Conestoga Lake. Thus, while the hypothesis is not strongly supported, it is not clearly disproven either. More detailed study is clearly needed but preferably without the inclusion of open space land as a non-farm land use.

Spatial Variables

Twelve measures of distance and road measures were taken from Ontario Department of Highways maps. If the locational sub-system as outlined in Part I, the distance measures should represent the downward slope of urban influence outward from cities and perpendicular to highways and other major roads. The mileage measures should represent the relative importance of paths. The distinction between east-west and north-south roads represents an attempt at measuring the corridor influence, and the counting of road junctions by blocks represents a measure of nodes in the transportation network. However, most of these measures did not contribute significantly to the factor analysis structure. Perhaps, if the study were confined to what has been outlined on the maps as the basic corridor, the results would provide more support for the underlying hypothesis. Several of these spatial variables are used later in a multiple regression model of urbanization development and do contribute significantly there.

The Factor Analyses

The cross-sectional analyses for 1941 and then 1966 will be presented and compared. The final analysis involves the longitudinal development matrix 1941-1966. The method of presentation follows Murdie's careful and detailed approach used in his Toronto study (Murdie, 1969).

A brief comment is made here on possible error in the data used. Since no sampling or interviewing is involved, all the possible error lies in the area of data recording and compilation. Such error largely cancels out since over 300 blocks are involved for the small area statistics. However, the possibility of error showing up for an individual block does exist. A number of internal editing checks were used to reduce such error possibility to a minimum.

Another possible weakness in the analysis is that for all variables, untransformed data was used; skewness does exist for some variables especially in 1941. Logarithmic or

some other transformation might have increased the proportion of total variance explained by the factor analyses.

The Cross-Sectional Analyses 1941 and 1966

Considerable similarity is exhibited by the factor structure of the Toronto to Stratford land space matrix for 1941 and 1966 (Table 7). The factors listed could readily be identified, named, and at least partially explained; the factors listed have at least four variables loading significantly and also have common cut-off points in per cent of variance explained of at least five per cent. All the factors used have eigen values of 2.0 or more; eigen values of 1.0 are usually considered statistically significant.

The per cent of total variance explained by these factors is approximately the same each year, being 49 per cent in 1941 and 46 per cent in 1966. For both years, the "best" three factors are the same—named respectively, *urban shadow, urban fringe,* and *open space land.* In 1941, these three factors accounted for 38 per cent of total variance and by 1966, they accounted for 39 per cent. The *other land* factor also occurred both years. In 1941, one additional independent factor—*rural location*—also readily explainable, is included to be consistent with the cut-off point of five per cent of variance explained.

TABLE 7

FACTOR STRUCTURE, TORONTO-STRATFORD LAND SPACE MATRIX
1941 AND 1966

	Per Cent of Total Variance Explained	
Factors	1941	1966
Urban Shadow	16.9	16.6
Urban Fringe	11.9	15.8
Open Space Land	8.7	6.7
Rural Location	5.8	
Other Land	5.6	7.3
	48.9	46.4

Thus, about one-half of the total variance in the Toronto to Stratford land space matrix is explained by a few factors. Altogether, over 80 per cent of the total variance could be explained using the eigen value cut-off point of 1.0; however, the result was 14 factors either not readily explainable or else consisting of one to three variables only. Several of these low variance factors loaded specifically only on spatial variables. For instance, one factor in both 1941 and 1966 has only two variables—miles of north-south highway and miles of north-south county road loading negatively and positively, respectively. Apparently, a number of township blocks have either one of these types of road or the other.

Factor 1 (1941 and 1966): Urban Shadow: Tables 8 and 9 list the factors loading significantly on the factors used in this analysis. These loadings are based on a normal varimax rotation solution thereby maximizing the value of the loading on one factor and minimizing it on all other factors. Factor loadings are equivalent to correlations between the factors and the original variables and may take on values between +1.0 and −1.0. Each factor is essentially uncorrelated with the other factors. The solution of the correlation matrix extracts one factor at a time; succeeding factors then explain as much as possible of the variance remaining after each successive factor is extracted. In considering maps of factor scores on successive factors, therefore, one must think of peeling of different underlying layers as successive factors are mapped. An analogy would be a landform map in which different types of landforms were removed in a sequence of maps or a different magnitude of landforms were shown from macro to successively smaller magnitudes until only the variance in micro landforms was shown.

Factor 1, *urban shadow,* has been so named because its significant loadings are on variables considered to be measures of urban shadow, that is, variables which indicate that urbanization pressures are developing. (The commonly accepted cut-off value of +0.50 or −0.50 is used to denote a significant loading.)

All 11 of the identical variables loading highly and significantly in 1941 and 1966 are non-farm land ownership variables. Ten of the 11 are measures of the landholding, non-resident and vacant land classes. Hence, a markedly similar factor structure holds for both years on this factor. Though not applied here, a high co-efficient of congruence should result. This index measures the degree of similarity between two factors and has recently been applied by Murdie (Murdie, 1969).

The three variables—landholding, non-resident, and vacant land, are thus measures of the spread of urban shadow, or in other words, represent the furthest outlying wave of the expansion of urbanization. By 1966, three population variables are added to the factor. Because of their polarity, I interpret these loadings as indicating intensification of the urban shadow process. Non-farm population loads positively and farm population loads negatively, suggesting that as the landholding, non-resident, and vacant land measures increase in magnitude, so does the per cent population non-farm but the farm population densities per acre decline. In the study area, this result, as the mapping of factor scores indicates, is partly related to Niagara Escarpment land and its close association spatially with the *urban shadow* factor.

Factor scores are derived by mathematical manipulation of the rotated factor loading matrix, the eigen values, and the standard score matrix. These scores range from zero to high positive or high negative values. They provide a spatial measure for each observation (township block here) on the factors derived from the factor analysis. Only the maps for the more important first two factors have been included in this report though preliminary maps of factor scores for all factors were prepared to aid in the analysis.

Figures 16 and 17, based on factor scores, show the spatial differentiation of the urban shadow dimension in 1941 and 1966. The factor scores are standardized measures of the township block on each factor. A division of class intervals was made to emphasize the higher negative and positive scores; thus a "neutral" class −0.49 to +0.49 is used to

TABLE 8

LAND SPACE MATRIX FACTOR ANALYSIS, 1941

Only variable loadings > 0.50 listed; 58 variables and 308 township blocks used.

Variable Number	Loading	Variable
	FACTOR 1	URBAN SHADOW
16.9%	12 variables	
16	0.68	Non-farm land ownership - non-resident parcels
17	0.78	Non-farm land ownership - vacant parcels
23	0.56	Non-farm land ownership - open space parcels
24	0.80	Non-farm land ownership - landholding parcels
26	0.85	Non-farm land ownership - non-resident acres
27	0.89	Non-farm land ownership - vacant acres
30	0.90	Non-farm land ownership - landholding acres
32	0.84	Non-farm land ownership - total non-farm acres
33	0.86	Non-farm land ownership - % non-resident of total land
34	0.87	Non-farm land ownership - % vacant of total land
37	0.88	Non-farm land ownership - % landholding of total land
39	0.83	Non-farm land ownership - % non-farm of total land
	FACTOR 2	URBAN FRINGE
11.9%	8 variables	
1	−0.79	Population - % non-farm
3	−0.88	Population - non-farm
6	−0.75	Population - % lots with some non-farm
13	−0.75	Land use - non-farm parcels
22	−0.91	Non-farm land ownership - residential parcels
28	−0.91	Non-farm land ownership - residential acres
35	−0.90	Non-farm land ownership - % residential of total land
41	−0.51	Assessment - % non-farm of total
	FACTOR 3	OPEN SPACE LAND
8.7%	7 variables	
8	−0.73	Land use - non-farm acres
9	−0.73	Land use - % non-farm
11	−0.52	Land use - average size of non-farm parcels in acres
19	−0.60	Non-farm land ownership - % open space of non-farm land
29	−0.92	Non-farm land ownership - open space acres
36	−0.92	Non-farm land ownership - % open space of total land
42	−0.70	Assessment - % non-farm land of total
	FACTOR 4	RURAL LOCATION
5.8%	5 variables	
4	−0.65	Population - farm density per acre
40	0.64	Assessment - % farm land of total
43	0.76	Assessment - % farm land of farm
47	0.64	Spatial - distance to nearest of Toronto or Kitchener-Waterloo
48	0.62	Spatial - distance to nearest urban place - a city
	FACTOR 5	OTHER LAND
5.6%	4 variables	
11	−0.54	Land use - average size of non-farm parcels in acres
21	−0.67	Non-farm land ownership - % other of non-farm
25	−0.59	Non-farm land ownership - other parcels
31	−0.80	Non-farm land ownership - other acres.

TABLE 9

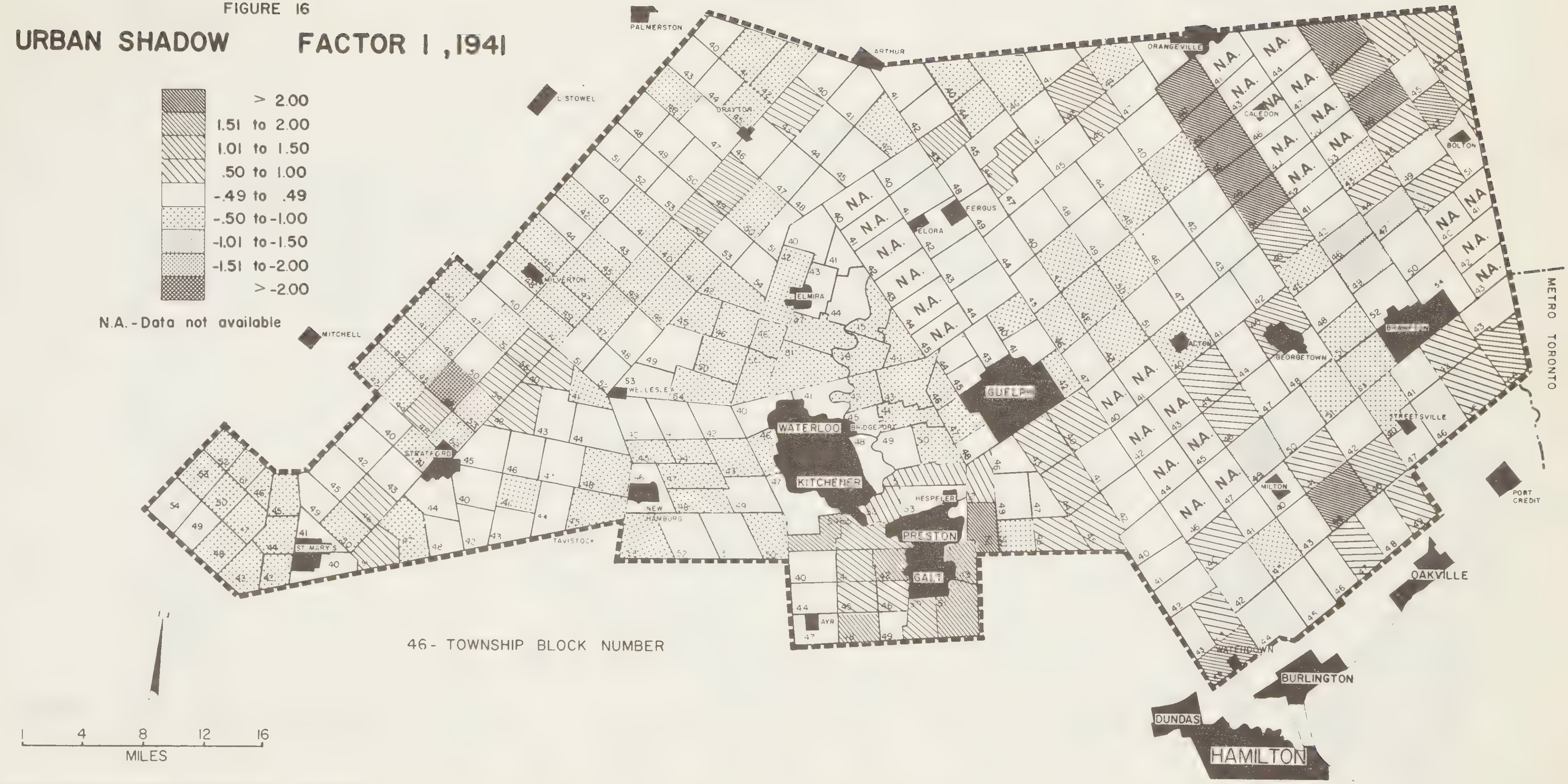
LAND SPACE MATRIX FACTOR ANALYSIS, 1966

Only variables loading > 0.50 listed; 58 variables and 334 township blocks used.

Variable Number	Loading	Variable
	FACTOR 1	URBAN SHADOW
16.6%	14 variables	
1	0.53	Population - % non-farm
2	−0.53	Population - farm
4	−0.63	Population - farm density per acre
16	0.63	Non-farm land ownership - non-resident parcels
17	0.50	Non-farm land ownership - vacant parcels
24	0.62	Non-farm land ownership - landholding parcels
26	0.89	Non-farm land ownership - non-resident acres
27	0.80	Non-farm land ownership - vacant acres
30	0.90	Non-farm land ownership - landholding acres
32	0.81	Non-farm land ownership - total non-farm acres
33	0.89	Non-farm land ownership - % non-resident of total land
34	0.82	Non-farm land ownership - % vacant of total land
37	0.87	Non-farm land ownership - % landholding of total land
39	0.79	Non-farm land ownership - % non-farm of total land
	FACTOR 2	URBAN FRINGE
15.8%	13 variables	
1	0.61	Population - % non-farm
3	0.91	Population - non-farm
6	0.61	Population - % lots with some non-farm
8	0.51	Land use - non-farm acres
13	0.85	Land use - non-farm parcels
16	0.61	Non-farm land ownership - non-resident parcels
17	0.71	Non-farm land ownership - vacant parcels
22	0.93	Non-farm land ownership - residential parcels
24	0.67	Non-farm land ownership - landholding parcels
28	0.85	Non-farm land ownership - residential acres
35	0.84	Non-farm land ownership - residential of total land
40	−0.64	Non-farm assessment - % farm land of total
41	0.68	Non-farm assessment - % non-farm of total
	FACTOR 3	OTHER LAND
7.3%	5 variables	
21	−0.69	Non-farm land ownership - % other of non-farm land
25	−0.66	Non-farm land ownership - other parcels
31	−0.93	Non-farm land ownership - other acres
38	−0.93	Non-farm land ownership - % other of total land
42	−0.65	Non-farm land assessment - % non-farm land of total land
	FACTOR 4	OPEN SPACE LAND
6.7%	4 variables	
19	−0.70	Non-farm land ownership - % open space of non-farm
23	−0.81	Non-farm land ownership - open space parcels
29	−0.91	Non-farm land ownership - open space acres
36	−0.90	Non-farm land ownership - % open space of total land

FIGURE 16

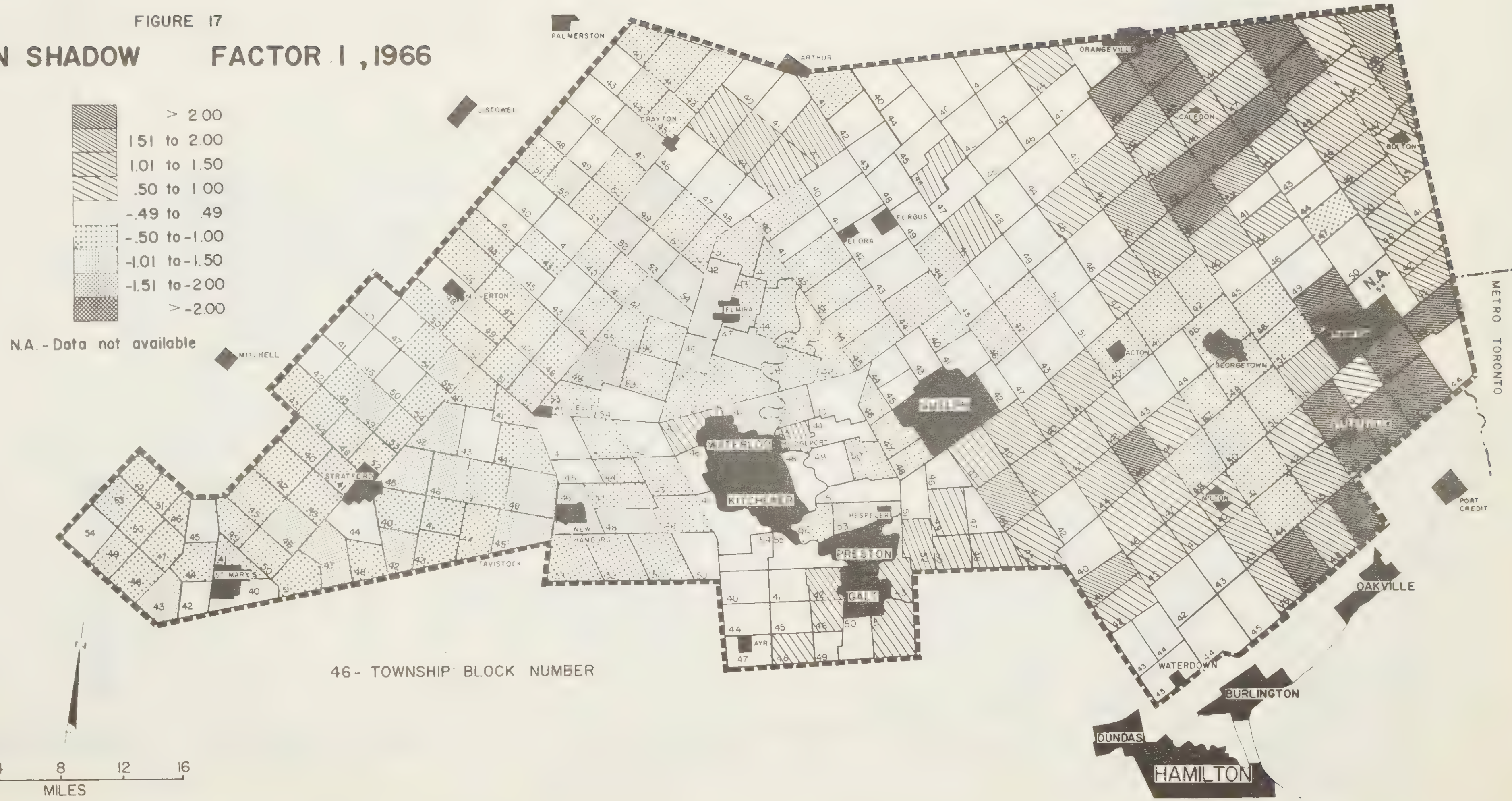
URBAN SHADOW FACTOR I, 1941



Source Compiled from Township Assessment Rolls - L. H. Russwurm

FIGURE 17

URBAN SHADOW FACTOR I, 1966



Source Compiled from Township Assessment Rolls L H Russwurm

contain the lowest factor scores. This "neutral" class contained 45 per cent of the township blocks for the *urban shadow* factor in 1941 but only 33 per cent in 1966. Partly this shift is from the inclusion of data not available in 1941 for three of the more urbanized townships (Nassagaweya, Toronto Gore and Caledon). Most of the shift has been to higher negative scores and by 1966, these accounted for 46 per cent of the township blocks while the per cent of high positive scores remained almost the same. This increasingly skewed distribution is a good indicator of the intensification of expanding urbanization in the urban corridor area in as much as spatially most of the negative scores occur north and west of Kitchener-Waterloo. Thus, inclusion of land outside the basic urban corridor accounts for many of the blocks with high negative scores.

Indeed, as Figure 16 shows, most of the blocks with higher negative scores are located north and west of Kitchener-Waterloo. Such scores indicate little urban shadow while higher positive scores outline areas of greatest urban shadows. Particularly noticeable is the continuous tongue of blocks starting between Guelph and Kitchener-Waterloo and extending to Milverton at the western edge of the study area. Other continuous blocks of higher negative scores are noted west of St. Mary's, northwest of Stratford, northeast of Guelph and between Georgetown and Brampton. Generally, these areas can be identified as having continuous areas of good farm land.

The spatial distribution of the higher positive factor scores (greatest amount of urban shadow) appears somewhat more disrupted than it probably is because of the townships with missing data for 1941. Nevertheless, the preponderance of high positive scores in the southern part of the Grand River Triangle of cities and in the area earlier noted as the fusing of urban corridors and the urban field of Metro Toronto is evident. The early core areas of urban shadow area, therefore, are around Galt-Preston, in the back slope and rougher land areas associated with the Niagara Escarpment, and north of Highway 5 towards Milton and Brampton.

The scattered blocks with high positive scores in the west and north central parts of the study area, in part reflect areas of open space land. This variable of open space land loaded significantly only in 1941 on the *urban shadow* factor and only for the number of parcels of open space land. Further detailed investigation would be needed to verify this suggested explanation.

By 1966, the spatial dimension of urban shadow had more or less solidified into a distinct pattern reflecting the key areas of this type of urban expansion pressure. The core areas seen in the 1941 pattern have expanded, especially the areas between Brampton and Metro Toronto and south of Orangeville. The hypotheses noted on this aspect of expanding urbanization have been supported. Thus, the major areas of urban shadow are associated with the urban field of cities, or are associated with more scenic rougher land less valuable for farming, or a combination of these hypotheses as in the Galt areas and southeast of Guelph.

The large continuous areas of higher negative scores west northwest and north of Kitchener-Waterloo show the limited impact of urban shadow to date in that area. The highest negative scores are around Elmira, the core of the Mennonite farming area. This area is a major part of the spatial core of livestock farming in western Ontario.

A much smaller area of low negative scores noted in 1941 in the Georgetown-Brampton area has expanded somewhat and reflects in part the strength of farming on this area of high capability farm land. This spatial pattern does support the hypothesis that areas of better farm land, especially with fewer owners, should be areas where the impact of urban shadow is delayed. A more detailed investigation is needed to fully substantiate this hypothesis.

The use of the factor analysis technique on the land space matrix data has helped provide a first detailed spatial differentiation of the urban shadow effect in western Ontario. As noted previously (Russwurm, 1964), the areal extent of urban impact in areas of good farmland is usually exaggerated. Really good farm land, unless it is immediately adjacent to built-up urban areas, tends to help return sufficient economic rent to farmers and thus they are more ready to resist the initial urban pressures, whatever form they take.

Factor 2 (1941 and 1966): Urban Fringe: This factor has been named *urban fringe* because it consists of a cluster of variables which measure the more concrete phenomena of expanding urbanization. Loading significantly for both 1941 and 1966 on this factor are three measures of non-farm population and three measures of residential land (see Tables 8 and 9). In addition, number of non-farm land use parcels and per cent that non-farm assessment is of total assessment load significantly in both years. Basically then, high scores on this factor should be spatially associated with main urban centres. Figures 19 and 20 verify this hypothesis. Note here that the negative signs on the loadings for 1941 for the *urban fringe* factor indicate only that all the variables are related, and are only a mathematical outcome of the rotated solution.

By 1966, five other variables also loaded highly on the *urban fringe* factor. Three are additional measures of non-farm land ownership namely, landholding, non-resident and vacant parcels. The inclusion of these variables indicates the more dynamic and greater effects of expanding urbanization by 1966. I interpret the inclusion of these variables as an indication of the lag between land acquisition by non-farm people and the time when they build. Upon building many of these parcels would become residential land. The remaining two variables added to the *urban fringe* factor by 1966, also reflect the greater intensity of expanding urbanization. The positive loading for non-farm land use acres indicates that much of this land occurs in the urban fringe; the relatively low value of 0.51 may be related to the fact that open space land is included as non-farm land use in this study and contains large acreages of land not located in urban fringe areas. The negative loading for per cent farm land assessment of total assessment is to some extent the converse of the positive loading for non-farm land assessment.

Using similar class intervals as for the *urban shadow* factor, the maps of factor scores for the *urban fringe* factor were derived. Since factors are independent of each other, the spatial patterns of two factors should not overlap greatly. Such is the case here.

For both 1941 and 1966, 50 per cent of the township blocks had factor scores between −0.49 and 0.49 (Table 10). The similarity of the distribution of the factor scores for both years is further seen, in that for both years, 32 and 18 per cent of the factor scores are greater than −0.49 and 0.49, respectively. As in the *urban shadow* factor, this skewed distribution with the greater number of negative than positive

TABLE 10

FACTOR SCORE DISTRIBUTIONS

FACTOR 1		URBAN SHADOW	
	1941	1966	1941-66
> –2.00	1	0	10
–1.51 to –2.00	0	2	7
–1.01 to –1.50	4	25	18
–0.50 to –1.00	97	109	44
+0.49 to – 0.49	144	110	143
+0.50 to + 1.00	34	33	40
+1.01 to + 1.50	12	30	24
+1.51 to + 2.00	7	7	13
+2.00	9	18	6
	308	334	307

FACTOR 2		URBAN FRINGE	
	1941	1966	1941-66
> –2.00	0	0	1
–1.51 to –2.00	0	0	0
–1.01 to –1.50	8	5	16
–0.50 to –1.00	90	104	108
+0.49 to – 0.49	155	168	112
+0.50 to + 1.00	26	22	19
+1.01 to + 1.50	12	12	19
+1.51 to + 2.00	9	7	15
> +2.00	8	16	17
	308	334	307

scores, probably also reflects the inclusion of land outside the basic urban corridor area.

The spatial differentiation of the *urban fringe* factor for 1941 is seen on Figure 18. That the township blocks scoring highest on the *urban fringe* factor are primarily associated with the environs of the urban centres is evident. The greater number of scattered blocks with high positive scores in 1941 than in 1966, results from the inclusion of hamlets, most of which had declined in population by 1966. Also, most blocks containing Niagara Escarpment land do not have high positive scores—an expected outcome because such blocks had high positive scores on the *urban shadow* factor.

Continuous areas of blocks exhibiting the highest negative factor scores and thus scoring low on the cluster of variables which make up the *urban fringe* factor, occur mostly across the north central part of the area in 1941, approximately circumscribed by a triangle whose apexes are Guelph, Palmerston and Orangeville. These blocks are mostly outside the basic urban corridor area. This triangular area then has a low non-farm population, little residential land and limited numbers of landholding, non-resident and vacant parcels.

The area between Brampton and Toronto is an area with higher negative scores where higher positive scores might be expected. The negative scores result primarily from the other land already represented by Toronto Airport in 1941. Hence, the variables loading highly on the *urban fringe* factor are of lesser importance in these blocks.

Another area with higher negative scores, consisting of eight contiguous blocks, occurs south of Guelph. Most of these blocks had high positive factor scores for the *urban shadow* factor. Putting the spatial patterns of the two factors together suggests that this zone south of Guelph had, by 1966, become a zone of urban shadow development—the forerunner of urban fringe development which by 1970 is showing up more and more.

Urban fringe development in 1941, that had actually taken place (high positive scores), is associated mainly with blocks adjoining urban centres—Highway 7 from New Hamburg to Kitchener-Waterloo, the backslope of the Niagara Escarpment from Burlington to Acton, five contiguous blocks from Bolton to Caledon East, and seven contiguous blocks north of Oakville (see Figure 19).

Major changes since 1941 have occurred only in the eastern part of the study area. The most significant intensification of *urban fringe* development is that on the backslope of the Niagara Escarpment from Burlington to Acton. Recall that residential land and non-farm population measures are the key variables in this factor and that residential land means land parcels of less than 10 acres in size. While parcels of landholding, non-resident, and vacant also load highly on this factor, other measures (percentage, acres) of these three variables do not. Hence, the interpretative conclusion is that significant urban fringe development has occurred in this area and has been marked by major fragmentation of land holdings. For the three townships — Flamboro East, Burlington, and Esquesing — containing most of these blocks, the number of non-farm land ownership parcels increased respectively from 57 to 877, from 94 to 1,253, and

FIGURE 18

URBAN FRINGE FACTOR 2, 1941

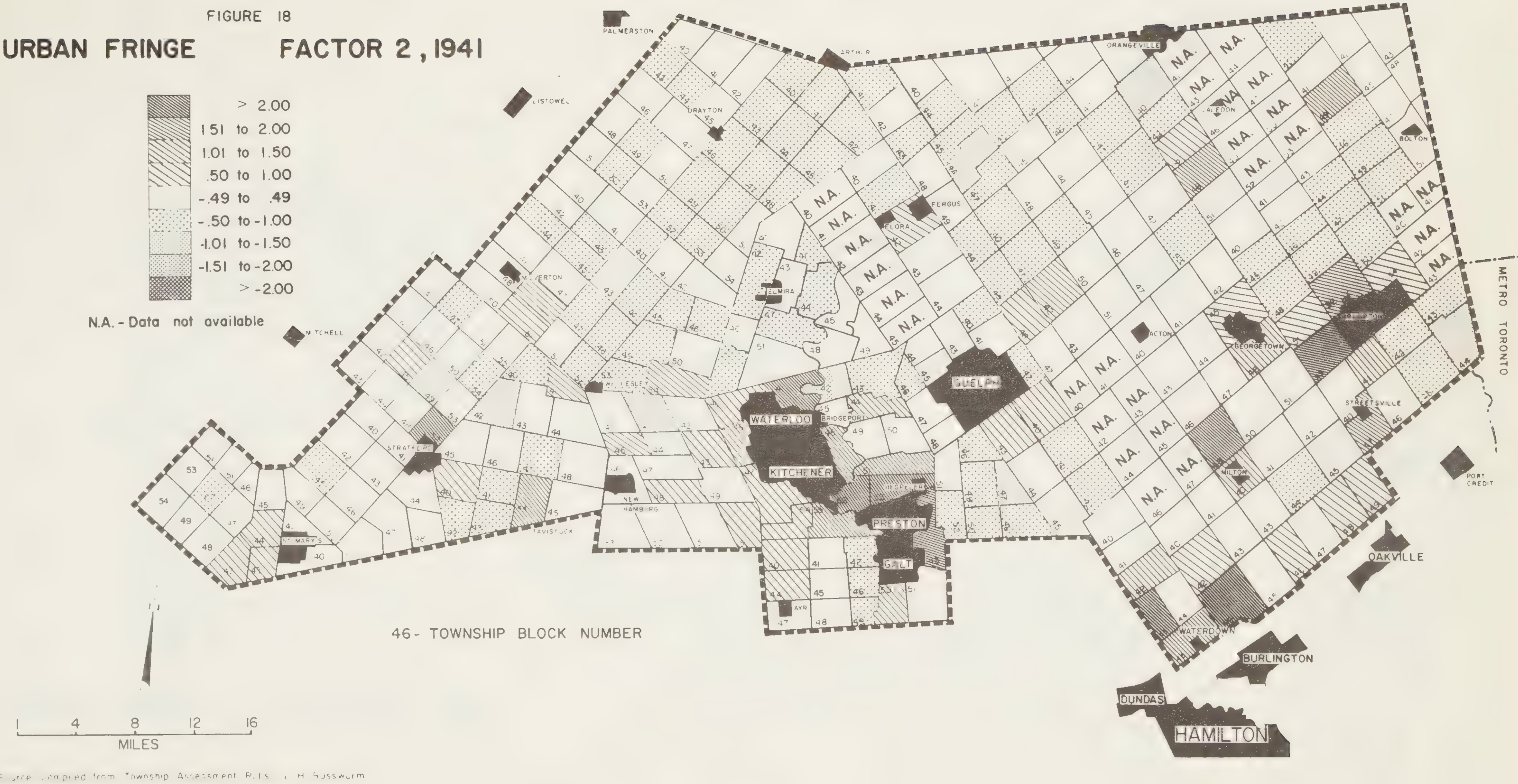
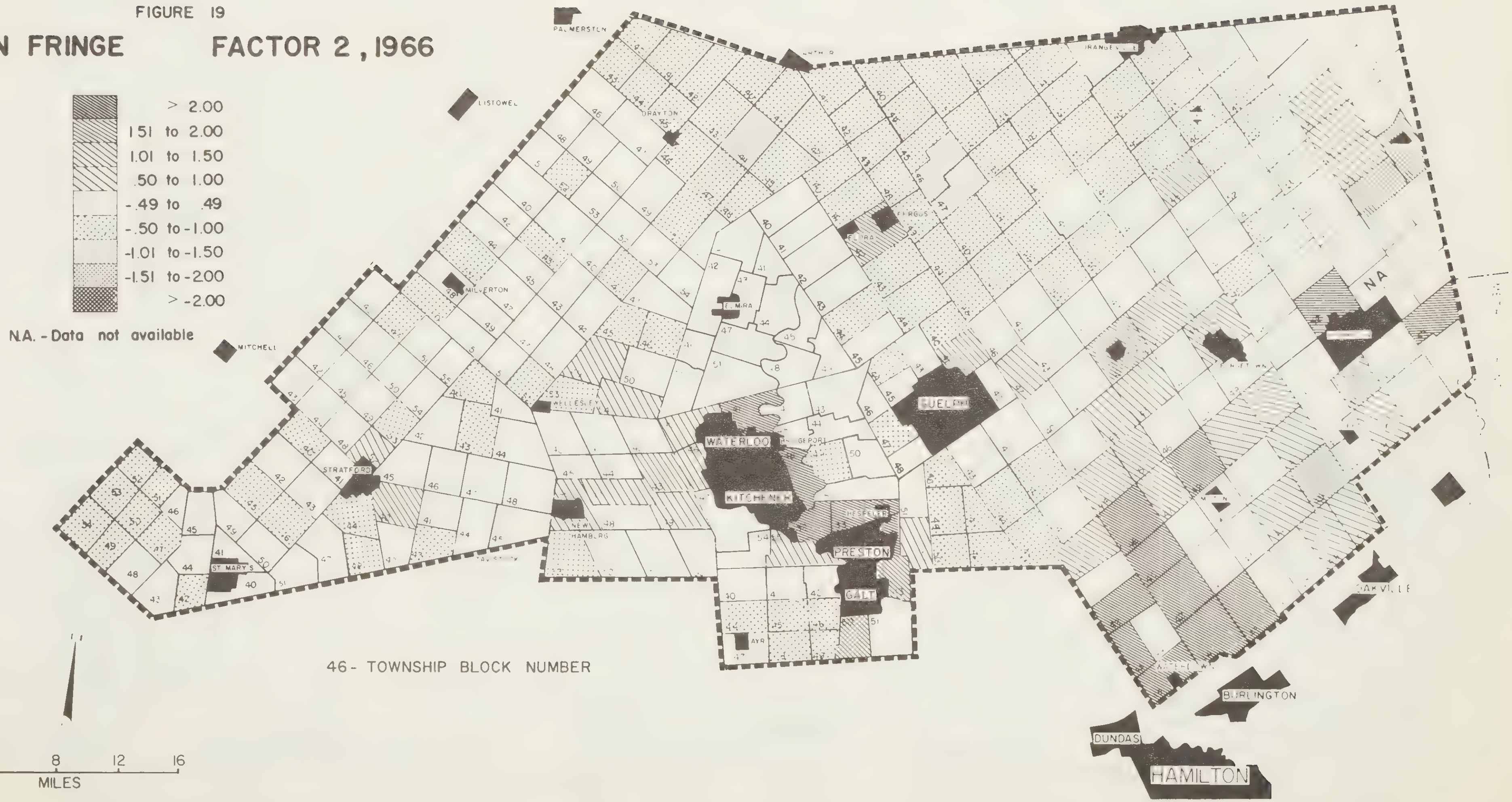


FIGURE 19

URBAN FRINGE FACTOR 2, 1966



Source Compiled from Township Assessment Rolls - L H Russwurm

from 143 to 1,126 over the 1941 to 1966 span. This rate of increase is approximately eleven-fold or about twice that of the study area. Clearly, urban expansion has taken over much of the Niagara Escarpment land. Certainly, the cluster of variables represented in the *urban fringe* and *urban shadow* factors are the major forces of expanding urbanization affecting the land space matrix. Three additional factors are, however, briefly discussed below.

Factor 3 (1941) and Factor 4 (1966): Open Space Land: Measures of this non-farm land ownership category dominated this factor, especially in 1966 when only one other variable loaded significantly (see Tables 8 and 9). While the *open space* factor accounts for less of the total variance explained in 1966 (6.7 per cent to 8.7 per cent in 1941), the actual acreage of open space land for the study area increased from about 5,000 acres to about 34,000 acres—a seven-fold increase. A preliminary map check of factor scores in 1966 showed that high positive scores represented blocks scoring high on all four measures of open space land. In 1941, this factor was somewhat more complex, including only three open space land variables along with four other variables (Table 8). Three of the variables measure non-farm land use and indicate the relatively greater influence that the larger size parcels of open space had on non-farm land use in 1941 as compared with 1966. Witness the loading of variable 11 which is a measure of the average size of non-farm parcels. Similar explanatory comments apply to the other variable, per cent non-farm assessment of total assessment, also included in the *open space* factor for 1941.

Factor 5 (1941) and Factor 4 (1966): Other Land: Contrary to the *open space* factor, this factor explains more of the total variance of the Toronto to Stratford land space matrix in 1966 (7.3 per cent) than it did in 1941 (5.6 per cent). Actual acreages of other land increased almost six-fold from 1941 to 1966 from about 4,000 acres to about 23,000 acres. All four measures of open space land, parcels, acres, per cent of non-farm land and per cent of total land, load highly on this factor in both 1941 and 1966. The added variable loading significantly in 1966 is the per cent that non-farm land is of total assessment. Presumably by 1966, the increased acreage of other land assessment has increased as a proportion of the total non-farm land assessment. Much of this other land is land being used for industrial mineral extraction or for airport use.

A basic interpretation of this factor is that other land (commercial, industrial, institutional) is strongly concentrated in a limited number of observation units (township blocks); this concentration of other land as noted above is reflected also in 1966 in the higher per cent of total assessment accounted for by non-farm land. A preliminary map of factor scores for 1966 verified this interpretation with the highest positive factor scores being the three blocks containing Toronto International Airport, the block containing the Waterloo-Wellington Airport east of Kitchener, and a number of blocks containing gravel, sand, or stone quarrying or manufacturing operations.

Factor 4 (1941): Rural Location: This factor contains a cluster of five variables and explains 5.8 per cent of the total variance. Even though only one of the variables loading significantly is negative and the other four are positive, this factor can be described as bipolar. The negative loading variable is farm population density per acre and the positive loading variables are two farm land assessment variables (farm land as a per cent of total, farm land as a per cent of farm) and two spatial variables (distance to

nearest of Toronto or Kitchener-Waterloo and distance to nearest urban place—a city). The interpretation is that as farm population densities decline, the proportion that farm land assessment contributes to total or to farm assessment increases. This relationship is simultaneously associated with distance to nearest city. Generally, the further from a city, the lower the farm population density and the greater the proportion of assessment contributed by farm land.

A preliminary map, not included in this report, shows a distinct concentric zone pattern with the area from Stratford to Elmira to Guelph forming the inner zone with higher negative factor scores. The second zone is a zone of neutral factor scores and the outer zone of higher positive scores follows the western and northern fringe of the study area. If farm population density is accepted as a measure of intensity of farm use, then this pattern supports the Von Thunen Theory. Since this factor disappears by 1966, further support is provided for the expansion of urbanization across much of the study area, creating a much more complex spatial pattern for the land space matrix.

The importance of the Mennonite farming area, as the core of the concentric zones referred to above, must be noted. Basically, for this factor, the Mennonite farming core area focussed on Kitchener-Waterloo, has higher farm population densities and simultaneously is close to cities and has a lower proportion of assessment attributable to farm land assessment.

The Longitudinal Development of the Land Space Matrix 1941 to 1966

This section extends the cross-sectional factor analysis presented above by considering the longitudinal development of the factor structure of the Toronto to Stratford land space matrix 1941 to 1966. The basis of this longitudinal analysis is the matrix of change for 43 variables for 307 township blocks. The change measure is simply the 1966 value minus the 1941 value.

The factor analysis of the matrix measuring change between 1941 and 1966 produced 10 factors accounting for 80.2 per cent of the total variance. Using the same cut-off criteria used in the cross-sectional analysis, that is, at least four variables and five per cent of total variance explained, only five factors (Table 11) are interpreted. Also, as in the cross-sectional analysis, only the factor scores for the first two factors, *urban fringe* and *urban shadow* are mapped.

TABLE 11

LONGITUDINAL DEVELOPMENT OF THE TORONTO TO STRATFORD LAND SPACE MATRIX, 1941 TO 1966

Factors	Per Cent of Total Variance Explained
1. Urban Fringe Development	18.4
2. Urban Shadow Development	18.1
3. Other Land	10.4
4. Open Space Land	7.7
5. Non-Farm Land Ownership Mix	5.9
	60.5

To date, multivariate techniques appear to have been applied to a change matrix in only two previous studies (Murdie, 1969, Sweetser, 1962). The results for the change model of the land space matrix are different than those produced for Metropolitan Boston and Metropolitan Toronto. These metropolitan studies, based on census tract areal units, had a lesser proportion of the total variance explained by the longitudinal analysis than by the cross-sectional analyses. Here, using the cut-off criteria noted above, the cross-sectional analyses explained only 49 and 46 per cent of the total variance while the longitudinal analysis explained 61 per cent of the total variance.

The factors summarizing the land space change matrix and the proportion of the total variance accounted for by each factor are given in Table 12. Considerable similarity exists between this factor structure and that of the cross-sectional factor structures. Such relationships are discussed below where the change factors are discussed individually.

Factor 1 (1941-1966): Urban Fringe Development: As could partly be expected from the greater proportion of total variance explained by the *urban fringe* factor in 1966 as compared to 1941 (16 per cent as compared with 12 per cent), this factor accounts for about the same amount of total variance in the change matrix as does the *urban shadow* factor, which was the first factor in both cross-sectional analyses. However, the *urban fringe* and *urban shadow* factors together are clearly the key factors explaining the land space matrix both from a cross-sectional and a longitudinal approach. This conclusion suggests considerable predictability of the land space matrix variables over time.

The *urban fringe development* factor, accounting for 18.4 per cent of the total variance, consists of a cluster of nine variables loading significantly, that is, greater than 0.50 (Table 12). Six of these nine variables occur in the *urban fringe* factor for both 1941 and 1966. These variables are two non-farm population measures (per cent and number), the non-farm land use measure (parcels), two non-farm residential land ownership measures (parcels and acres) and one non-farm assessment measure (per cent non-farm of total). The remaining three variables loaded only on the 1966 *urban fringe* factor. They consist of the three intercorrelated non-farm land ownership measures of non-resident, vacant, and landholding parcels. By definition, non-resident land consists of either landholding or residential, and vacant land is a sub-class of landholding. Hence, the potential for intercorrelation exists.

Basically, this factor says that the urban fringe changes show close relationships between increases in non-farm population, in residential acres, and in numbers of landholding, non-resident and vacant parcels. Logically, these increases are accompanied by non-farm assessment accounting for an increasingly greater per cent of total assessment.

Factor 2 (1941-1966): Urban Shadow Development: From a process standpoint, urban shadow development is the forerunner of urban fringe development. The finding that these two aspects of the expansion of urbanization across land space can be analytically separated, i.e. factors are independent or essentially uncorrelated is a significant outcome of this research. That the same result occurs for the change matrix is equally encouraging. Such separation has implications for regional planning because

TABLE 12

LAND SPACE CHANGE MATRIX FACTOR ANALYSIS, 1941 TO 1966

Only variable loadings >0.50 are listed; 43 variables and 307 township blocks were used. All the spatial variables were deleted because values remained almost the same for 1941 and 1966; three assessment variables were also deleted because of problems in interpreting what the change meant. These variables also did not load significantly on the major factors for 1941 or 1966 and thus contributed very little to the overall explanation of variance.

Variable Number	Loading	Variable
	FACTOR 1	URBAN FRINGE DEVELOPMENT
18.4%	9 variables	
1	0.55	Population - % non-farm
3	0.91	Population - non-farm
13	0.87	Land use - non-farm parcels
16	0.63	Non-farm land ownership - non-resident parcels
17	0.69	Non-farm land ownership - vacant parcels
22	0.94	Non-farm land ownership - residential parcels
24	0.68	Non-farm land ownership - landholding parcels
28	0.84	Non-farm land ownership - residential acres
41	0.67	Assessment - % non-farm of total
	FACTOR 2	URBAN SHADOW DEVELOPMENT
18.1%	11 variables	
16	0.61	Non-farm land ownership - non-resident parcels
17	0.53	Non-farm land ownership - vacant parcels
24	0.59	Non-farm land ownership - landholding parcels
26	0.89	Non-farm land ownership - non-resident acres
27	0.88	Non-farm land ownership - vacant acres
30	0.86	Non-farm land ownership - landholding acres
32	0.76	Non-farm land ownership - total non-farm acres
33	0.87	Non-farm land ownership - % non-resident of total land
34	0.87	Non-farm land ownership - % vacant of total land
37	0.81	Non-farm land ownership - % landholding of total land
39	0.72	Non-farm land ownership - % non-farm of total land
	FACTOR 3	OTHER LAND
10.4%	6 variables	
7	0.64	Land use - farm acres
8	−0.61	Land use - non-farm acres
9	−0.62	Land use - % non-farm
25	−0.65	Non-farm land ownership - other parcels
31	−0.86	Non-farm land ownership - other acres
42	−0.75	Assessment - % non-farm land of total
	FACTOR 4	OPEN SPACE LAND
7.7%	4 variables	
19	−0.57	Non-farm land ownership - % open space of non-farm land
23	−0.69	Non-farm land ownership - open space parcels
29	−0.89	Non-farm land ownership - open space acres
36	−0.88	Non-farm land ownership - % open space of total land
	FACTOR 5	NON FARM LAND OWNERSHIP MIX
5.9%	4 variables	
14	0.75	Non-farm land ownership - % non-resident of non-farm land
15	0.72	Non-farm land ownership - % vacant of non-farm land
18	−0.62	Non-farm land ownership - % residential of non-farm land
20	0.81	Non-farm land ownership - % landholding of non-farm land

areas can be delineated for these two phases of expanding urbanization as structured by the private enterprise system; such delineation will aid in guiding the direction desired for expanding urbanization if proper implementation tools and plans are made available.

All eleven of the variables loading significantly on the *urban shadow development* factor loaded similarly in both 1941 and 1966. The *urban shadow development* factor, however, accounts for a slightly higher proportion of total variance at 18.1 per cent than the *urban shadow* factors did in 1941 (16.9 per cent) or in 1966 (16.6 per cent).

The cluster of variables which comprise this factor are all non-farm land ownership variables. Nine of the eleven variables consist of the triumvirate of landholding, non-resident and vacant land, measuring number of parcels, acres and per cent of total land. The two other variables, total non-farm acres and per cent non-farm of total land, partially result from the magnitude of the landholding variable as a sub-class of non-farm land ownership in as much as landholding accounted for approximately 80 per cent of the non-farm owned land in both 1941 and 1966. Presumably then, the single variable landholding ownership should be a good predictor of urban shadow development. This hypothesis is tested in Part 9 where an urban corridor system locational model is developed.

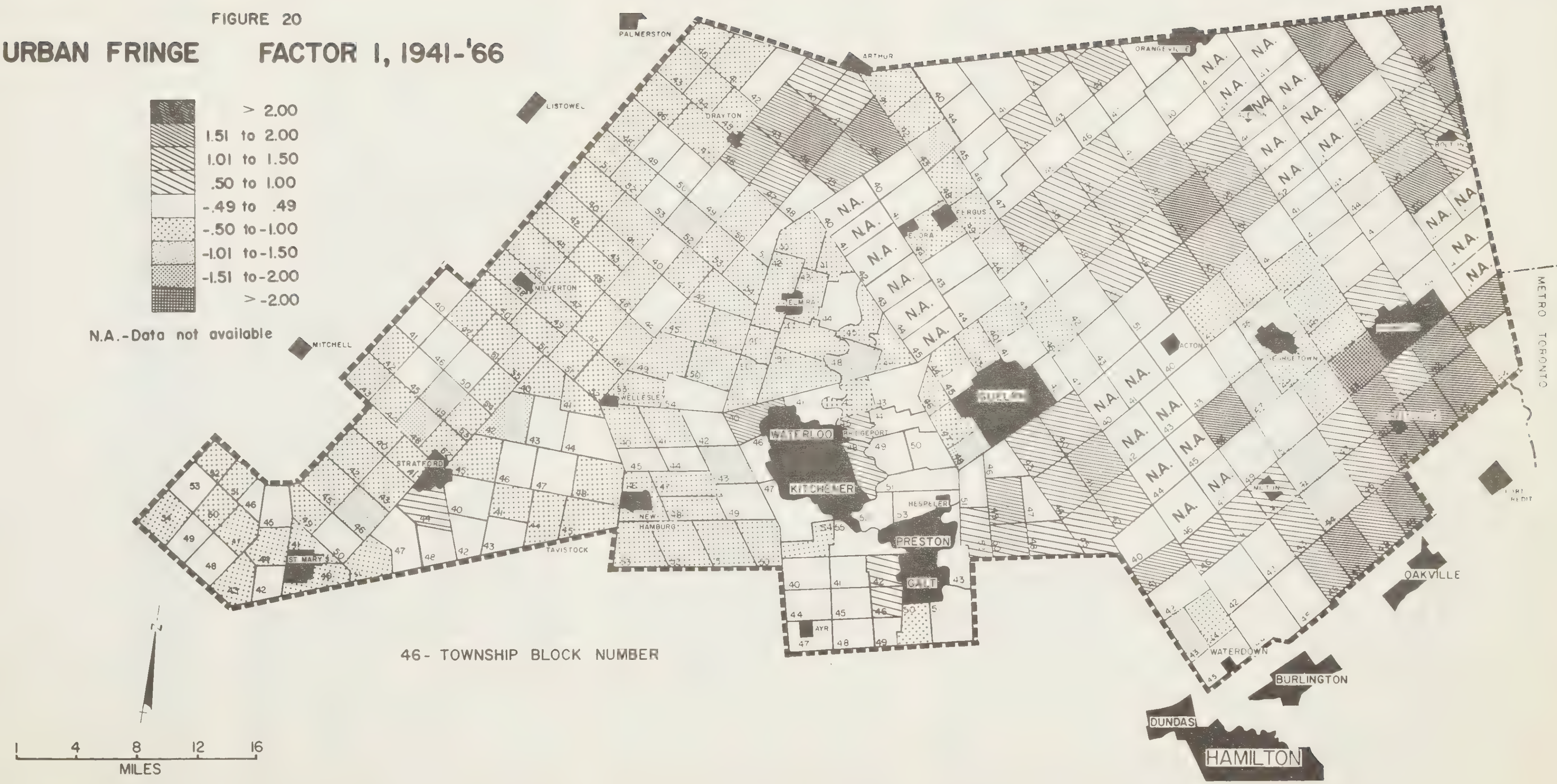
Spatial Differentiation of the Urban Fringe Development and Urban Shadow Development Factors: Figures 20 and 21 are maps based on the factor scores of these two factors. As is evident from Figure 20, a rather distinct spatial pattern of change has occurred for urban fringe development. Maps showing the spatial patterns for the cross-sectional urban fringe factor (Figures 18 and 19) emphasized the areas with maximum development (high positive factor scores); such areas mainly occurred adjacent to the major urban centres. The change map for the *urban fringe* development factor, emphasizing magnitude of change, differs from the cross-sectional maps. Thus, the noticeable area of urban fringe already present for the Kitchener-Waterloo-Preston-Galt area in 1941, shows up mainly in the "neutral" category with factor scores of –0.49 to 0.49.

Four areas of contiguous township blocks are singled out as areas of important urban fringe type development. Two are adjacent to Guelph and the Metro Toronto-Brampton-Oakville rectangle; and two occur in the northern part of the study area. It is assumed that the zone of high positive factor scores extends from the Erin area to Bolton, even though data is missing for parts of Caledon Township. The second northern urban fringe development zone is one of nine contiguous blocks between Arthur and Conestoga Lake. As noted earlier in the comments on the map showing the per cent that landholding is of total land (Figure 12), my only plausible suggestion for this development is land being bought for access to the two recreation areas of Belwood and Conestoga Lakes. Recall that one element of the *urban fringe* development factor is the increase in number of parcels in the non-farm ownership categories of landholding, non-resident, and vacant land.

The two areas of important urban fringe type development adjacent to cities are spatially associated with Highway 401. The zone adjacent to Guelph is concentrated in Puslinch Township—along Highway 6 to the Highway 401 interchange. Most of one

FIGURE 20

URBAN FRINGE FACTOR I, 1941-'66



Source. Compiled from Township Assessment Rolls - L. H. Russwurm

FIGURE 21

URBAN SHADOW FACTOR 2, 1941-'66

block, block 43, was annexed by the City of Guelph in 1967. This zone is also the site of a proposed satellite town. Like the Guelph zone, the expansion zone of Metro Toronto lies athwart Highway 401, extending south to Highway 5. Moreover, the northern zone previously noted from Bolton to Erin probably also extends into Metro Toronto to the south. Missing data make analysis of the spatial pattern somewhat uncertain.

The dominant area of high negative factor scores, i.e. little urban fringe type development 1941-1966, consists of most of the blocks west of Kitchener-Waterloo with the Mennonite farming area of Woolwich Township again prominent. Probably a continuation of this (missing data problem again) is the area north of Guelph. The third area is the Georgetown-Brampton area noted on several other maps earlier.

Although the *urban shadow development* factor accounted for almost a similar proportion of total variance explained as did the *urban fringe* development factor, the spatial pattern of change is rather a checkerboard one with no large areas of continuous development or lack of such development (Figure 21). The *urban fringe* factor has been characterized as one exhibiting the more noticeable concrete development of expanding urbanization on the landscape—the residential acreage, non-farm population, and parcels of landholding, non-resident and vacant land. The *urban shadow* factor is a more abstract measure of expanding urbanization, largely a forerunner of urban fringe that is to come.

The *urban shadow development factor* mainly indexes the magnitude of non-farm ownership of land since the variables loading for non-farm land ownership measure size mostly but for the *urban fringe development factor* measured numbers of parcels only. Thus, the measures of landholding, non-resident, vacant, and total non-farm land loading highest (Table 12) are measures of acres and concomitantly of per cent of total land. Presumably, this difference in the measures of landholding, non-resident, and vacant between the *urban fringe* development and the *urban shadow* development factor, contributes to the different types of spatial patterns. My hypothesis is that the urban fringe development pattern tends to be more continuous and more predictable because it is a later, more concrete stage of the land conversion process; the *urban shadow* development pattern as an incipient, less concrete stage, is more discontinuous and irregular. Presumably, the urban shadow pattern could be simulated satisfactorily since it probably follows a diffusion process spreading outward from individual nodes (Brown, 1968).

Factor 3 (1941-1966): Other Land: As in the 1966 factor analysis, the *other land* factor is the third factor. It consists of a cluster of six variables explaining 10.4 per cent of the total variance (Table 11). Only two measures of other land, parcels and acres, load significantly; these two variables are also the only two variables which were part of the *other land* factor for both 1941 and 1966. The structure of change for this factor is thus more complex than appeared for the cross-sectional analyses.

Of the remaining four variables, three are measures of land use. Non-farm acres and per cent of total land use non-farm load negatively while farm acres load positively, indicating the expected relationship of farm and non-farm variables, i.e. when one increases the other decreases. None of these land use variables loaded significantly in

either 1941 or 1966. The final variable non-farm land as a per cent of total assessment was also included in the other land factor in 1966.

The basic interpretation of this factor is that increases in other land (acres and parcels) by township block were accompanied by an increase in non-farm land use acres and the per cent that non-farm land use accounted for of total land. One concomitant result is that non-farm land accounts for a higher proportion of total assessment; a second concomitant result is that land use in farm acres declines.

Factor 4 (1941-1966): Open Space Land: This *open space land* factor accounting for 7.7 per cent of the total variance has the identical variables loading significantly that loaded similarly in 1966. These variables are all four measures of open space land, acres, parcels, per cent of non-farm land, and per cent of total land. As noted earlier, the *open space land* factor in 1941 (Table 8) had several other variables loading significantly but these were measures affected by open space land.

Thus, the interpretation of this factor from the change matrix is again straightforward. It indicates that increase in open space land has been concentrated in a limited number of blocks, most of which are associated with major conservation authority developments like the Conestoga Lake or Clairville reservoir areas.

Factor 5 (1941-1966): Non-Farm Land Ownership Mix: A fifth longitudinal development factor was extracted that explained more than five per cent of the total variance. It has been identified as a *non-farm land ownership mix factor* in that all four variables loading significantly are per cent measures of non-farm land ownership, respectively, for non-resident, vacant, landholding and residential land (Table 11). It is a bipolar factor with residential per cent loading negatively and the interrelated triumvirate of landholding, non-resident, and vacant land loading positively.

A check of the raw data showed that this factor identifies blocks where residential land increased its proportion of non-farm land ownership while landholding, non-resident, and vacant decreased in proportion. For factor scores, the result is high negative scores. As with bipolar factors the converse, residential land declines in proportion while landholding, non-resident, and vacant land increase their proportion, also occurs. The preliminary map of factor scores indicated rather a checkerboard pattern. As noted above, as successive factors are taken out of the matrix, the spatial pattern can ordinarily be expected to be less distinct.

Summary Comments

Change in the land space matrix was investigated by factor analysis both cross-sectionally and longitudinally. Through the cross-sectional analysis, change was inferred between 1941 and 1966; through the longitudinal analysis, change was analyzed more directly. The 25-year time period involved covers the period before real urban expansion began in the study area and includes the rapid post-war urban expansion developments.

The two most significant results are the relative stability of the structure of the land space matrix, and the fact that separate urban fringe and urban shadow factors

emerged in all three analyses. Theoretically, this result suggests that threshold levels can be identified for urban fringe development which is considered a follow-through process to the initiating process of expanding urbanization, that of the urban shadow process. Empirically, it suggests that for regional planning purposes, boundary zones of administrative units should recognize boundary zones between urban fringe, urban shadow and rural areas. Finally, note that this analysis is a locational and not a flow analysis and so measures only the one major sub-system of the urban system. The analysis has provided an objective descriptive model of expanding urbanization of the land space matrix as based on assessment roll variables.

PART IV

EXPANDING URBANIZATION AND SELECTED AGRICULTURAL ELEMENTS

In our complex industrial society of today, interactions between agriculture and urbanization are both direct and subtle. Clearly evident is the interactional movement of agricultural products to the urban area both for direct consumer use and as raw materials for further processing. Similarly evident are the services and goods provided for the farmer by the central place activities of villages, towns and cities which are investigated in Part V. Aside from these direct interactions, indirect effects of urbanization such as the urban shadow factor noted in the analysis of the land space matrix also occur. In this part some of these indirect effects are investigated.

Many words have been written on the possible effects, both deleterious and beneficial, of urbanization influences on farming in areas close to cities. A good general discussion of expanding urbanization and its influences on farming in nearby areas is found in an article by Gaffney (Gaffney, 1958). The interactions between agriculture and urbanization were strongly posited by a prominent agricultural economist, T.W. Schultz. He hypothesized with supporting evidence, that inequality in farm income in the United States is not a result of original differences in soil or the quality of the population, but rather is attributable to the geographical position of agricultural areas in relation to major centres or urban-industrial development (Schultz, 1953).

Two specific studies using townships as areal units have been done in the study area. One is Plewes' study of urbanization in Albion township (Plewes, 1967); the other is Tennant's study of Toronto Gore township (Tennant, 1968). Both these studies deal with the impact on the farm residents and are particularly concerned with the urban shadow effect. Though general in nature, Patterson's recent article on Ontario's disappearing agricultural land is also worth noting (Patterson, 1968). Other pertinent studies are noted in my article in Land Economics (Russwurm, 1967).

The analysis of the agricultural data for 1941 and 1966 involves four stages. First, simple linear correlation is used to provide correlations between selected agricultural elements and expanding urbanization, using mainly Census of Canada data. Second, a factor analytic model is presented based on a mix of variables from both Census of Canada and Assessment roll data. Third, several multiple correlation models are utilized to clarify combined relationships between the selected agricultural elements. Fourth, the loss of improved land which is usually stressed as a summation effect of urbanization on agriculture is analysed. For all these stages, the real interest lies in the cross-sectional changes that have occurred between 1941 and 1966.

A Simple Linear Correlation Approach

For this correlation analysis the assumption is made that the agricultural elements selected for study are impinged upon by expanding urbanization. From the analysis of change in the agricultural elements, evidence is obtained on the assumption made for the correlation analysis. Before presenting the results of the analysis, hypotheses

connected with expanding urbanization and the selected agricultural elements are outlined.

Variables and Hypotheses

Expanding urbanization as the independent variable in the correlation analysis is measured by the surrogate variable of 1 Per Cent of population non-farm. Non-farm population is considered to be the best single measure of expanding urbanization available. Two simultaneous measures are utilized: 1) Census data: use of which counts as non-farm population, all non-farm inhabitants including those living in the 63 unincorporated villages defined as minor urban nodes for this study; 2) assessment roll data are used which exclude the population of the 63 unincorporated villages areally defined for this study (i.e. all survey lots containing part of the village). The assessment roll population data are also based on similar areas for 1941 and 1966, as noted in Part IV.

In using the percentage of population that is non-farm, the assumption is made that it provides a useful measure of the external spread and influence of urbanization in an agricultural area. It is further assumed that the increase of non-farm population in the townships provides an indirect measure of the population increase of the cities and towns in the study area. That is, the urbanization impact is considered to be proportional to the size of the urban centre. Dot maps of non-farm population of the Hamilton-London corridor area 1941 and 1961 supported this assumption (Russwurm, 1964).

The first four variables discussed occur in previous literature and have been tested in the Hamilton to London corridor area for the 1941-1961 period (Russwurm, 1967). Comparisons will be made later of those results and the present ones in the Toronto to Stratford corridor area. The remaining six variables are first tested in the present study. A complete list of all variables used in this part is included in Table 13.

1. Per cent Rented Land of Farm Land

The hypothesis is that as non-farm population increases, an increasing proportion of farm land will be rented. Two factors are involved: 1) more land comes under the control of land speculators who may rent the land to farmers as they await urban conversion opportunities; 2) because of higher land values and the possibility of conversion to urban uses the bona fide farmer may not wish to, or may not be able to, afford to buy land.

2. Acres of Improved Land Per Farm

Improved land by census definition includes cropland, improved pasture, fallow land and other improved land (farmstead and lanes, idle land, sod farm land). As the per cent of non-farm population increases, the acreage of improved land per farm is expected to decrease. Underlying this hypothesis is the assumption that some farms will be broken into smaller parcels as land is sold for non-farm uses — an assumption supported in the land space matrix analysis. Also, specialized agricultural land uses

oriented towards nearby cities are apt to develop on smaller parcels of land. Examples are sod farms, poultry farms and market garden farms.

3. Per Cent Small Fruits, Vegetables and Nursery Products of Improved Land

Since the market for these products is largely in nearby urban areas, it is hypothesized that as urban demand increases, the per cent of improved land devoted to these crops will increase also. Over time, however, the possibility of increased productivity per acre, which would counter an acreage increase has to be recognized. Since acreages for this category now have to be obtained by special census tabulation, the variables – field crops not reported plus potatoes, are also included as a possible alternative measure.

4. Value of Farm Land and Buildings Per Acre of Improved Land

Capitalization per acre of improved land increased approximately five times from 1941 to 1966. No adjustment to a constant dollar value is made in this analysis because the concern is with variations in farm capitalization in relation to non-farm population increases rather than with the increase in farm capitalization *per se*.

The hypothesis is that the greatest increases in farm capitalization should occur in townships having the greatest increase in non-farm population. The reasoning behind this hypothesis is that urban growth tends to drive up the dollar value of nearby land. Moreover, as farm land is lost to urban uses, the remaining farm land being scarcer, should appreciate in value from an agricultural viewpoint also.

The value of land and buildings reported in the Census of Canada is an estimate of the market value given by the farm operator of his land and buildings for agricultural purposes. In the Census of Canada 1966, Vol. IV, (4-2) p. viii, it is vaguely hinted that the capitalization values reported may be influenced by nearness to cities and towns. For 1961, the Census of Canada, definitely noted that capitalization values reported were influenced by nearness to cities and towns.

5. Per Cent Full or Part Tenant Farms of Total Farms

For this variable the hypothesis is similar to that for rented land. More tenant arrangements can be expected as non-farm influences increase. Tied in with this hypothesis, however, is the increasing size of farm operations which, from a purely agricultural standpoint, would encourage some leasing to avoid tying up too much capital in land.

6. Per Cent Improved Land of Farm Land

Two conflicting notions can be postulated about the relationship of this variable and per cent population non-farm. On the one hand, using a Von Thunen type model, increasing specialization and consequently higher percentages of improved land could be expected. Such specialization, however, will probably concentrate on selected sites having particular resource or locational advantages. On the other hand, urban fringe

and urban shadow impact could lead, via land speculation, to idle farm land and abandonment of poorer land in anticipation of urban development. The hypothesis settled upon is that the per cent improved land will decrease as non-farm population increases.

7. Per Cent Field Crops not Reported Plus Potatoes of Improved Land

The hypothesis here is the same as for small fruits, vegetables and nurseries; thus, as non-farm population increases, so should the acreages in this category. This derived variable is included because special tabulations from the Census of Canada are now required to obtain data on small fruits, vegetables and nurseries at the township level. It is derived by totalling field crops reported excluding potatoes, subtracting from total field crops and adding in the potato acreages. In the townships of the study area, this is a feasible surrogate for small fruits, vegetables and nurseries, because other field crops not reported at the township level, like tobacco and beans, are almost non-existent.

8. Per Cent Other Improved Land of Improved Land

This variable refers to acreages in barnyards, home gardens, lanes and roads on farms, to idle land, to newly broken land and to sod farm acreages. More of this land may be expected as non-farm population increases using the oft-stated notion that urban growth leads to land lying idle as conversion to urban uses is expected. Certainly a lag period occurs between the time the land is bought for urban uses and the time it is actually converted. Such acreage increases, using this hypothesis, should occur mainly from idle land and from sod farm acreages.

9. Per Cent Woodland of Farm Land

The hypothesis tested is that more woodland will occur as non-farm population increases. As noted in the analysis of the land space matrix the urban shadow factor is more prominent in areas of rougher land; such areas will often contain wooded land. Also, the possibility exists of poorer land, though still reported as farm land, being abandoned and reverting to woodland as urbanization pressures increase (Gottmann, 1961). For whatever reason, this process has noticeably operated in Albion, Caledon and Puslinch townships.

10. Per Cent Other Unimproved Land of Farm Land

This variable is complementary to woodland as the two categories combined make up the unimproved farm land. It includes natural pasture (never cultivated), brush pasture and areas of slough, marsh and rocky land. Like the woodland variable, increased acreages may be expected for similar reasons as non-farm population increases.

Results of the Correlation Analysis

Results of the correlation analysis are presented in Table 13 which also includes, for comparative purposes, data on the Hamilton to London area. For the Toronto-Stratford area 30 townships are used in 1966 but because of missing assessment roll data only 27 townships are used in 1941; for the Hamilton-London area 26 townships are used for both years.

For the four selected agricultural elements based on census data earlier tested in the Hamilton-London area, comparative results are rather similar though correlation coefficients are higher in the Toronto-Stratford area, except for one variable (Table 13). Particularly suggestive are the considerably higher coefficients for per cent rented land of farm land and value of farm land and buildings per acre. Such results support the hypothesis and indicate that other things being equal between the two corridor areas, the urban effect may be intensifying. Clearly high proportions of non-farm population, rented land and capitalization value go together in 1966, as suggested in the hypothesis.

TABLE 13

CORRELATION OF SELECTED AGRICULTURAL ELEMENTS AND PER CENT POPULATION NON-FARM BY TOWNSHIP

AGRICULTURAL ELEMENT[a]	Toronto-Stratford[b] 1941	Toronto-Stratford[b] 1966	Toronto-Stratford[c] 1941	Toronto-Stratford[c] 1966	Toronto-London[c] 1941	Toronto-London[c] 1966
1. Per cent rented land of farm land	−0.217	0.744**	0.077	0.736**	0.073	0.384 *
2. Acres of improved land per farm	−0.510**	−0.514**	−0.581**	−0.470**	−0.534**	−0.512**
3. Per cent small fruits, vegetables & nurseries of improved land	0.333	0.432*	0.519**	0.346	0.298	0.320
4. Value of farm land & buildings per acre of improved land	0.431*	0.778**	0.635**	0.807**	0.642**	0.678**
5. Per cent full or part tenant farms of total farms	−0.062	0.704**	0.161	0.696**		
6. Per cent improved land of farm land	−0.324	−0.454*	−0.294	−0.305		
7. Per cent field crops not reported plus potatoes of improved land	0.048	0.334	0.215	0.235		
8. Per cent other improved land of improved land	−0.291	0.199	−0.313	0.019		
9. Per cent woodland of farm land	0.286	0.245	0.161	0.144		
10. Per cent other unimproved land of farm land	0.286	0.500**	0.331	0.349		

[a] All data are derived from the Census of Canada.

[b] Non-farm population from assessment rolls.

[c] Non-farm population from Census of Canada.

**Significant at the 0.01 probability level.
*Significant at the 0.05 probability level.

Still significant but with a declining coefficient is the acres of improved land per farm. Hence acreages of improved land per farm tend to be smaller in townships with a higher proportion of non-farm population. Here the change is similar in the Toronto-Stratford area as the correlation coefficient has declined 0.004 compared with

a decline of 0.022 in the Hamilton-London area. How much of the decline can be related to the additional five years from 1961 to 1966 is unknown but is being investigated.

The variable per cent small fruits, vegetables and nurseries of improved land had a significant coefficient in 1941 but declined to just under significance at the five per cent level by 1966 in the Toronto to Stratford area. Though acreages increased somewhat from 1941 to 1966 (6,449 to 7,731 acres, Oakville included) the per cent of improved land in these specialized crops increased only slightly from 0.6 per cent to 0.8 per cent. In part this slight percentage increase relates to the exclusion of Oakville in the 1966 per cent figures. (Oakville is excluded in 1966 because of some missing data.) A much greater acreage increase was noted in the Hamilton to London area where acreages had doubled since 1941. In both corridor areas, the majority of the acreage was located in townships directly bordering the cities.

When per cent non-farm population (Assessment rolls) is used (first column Table 13) some changes are noted but not stressed. Recall that for non-farm population taken from the assessment rolls, population in the survey lots surrounding the 63 unincorporated villages and the population of the node of the village itself are excluded and that a constant 1966 boundary is used around towns and cities for both 1941 and 1966. Thus, the non-farm population figure from the assessment rolls should be more conservative with the exclusion of the unincorporated village population and some urban fringe population. For the data used this procedure raises questions because the Census totals refer to the township areal extent which varies between 1941 and 1966 and is, of course, usually not the same as the comparatively defined assessment roll area. Nevertheless, the correlation results are included: (1) to show that the changes are not startling and in most cases are of same order of magnitude as for non-farm population (Census) and thus assessment variables can reasonably be combined with Census variables in a factor analysis; (2) on the basis that an interaction is being tested which may be modified by the discrepancy in areal limits but which is not really changed; (3) on the basis that where results do differ, it shows that the proportion of non-farm population in the included and excluded area does differ generally for the study area. For instance, interpret the increased correlation for the per cent small fruits variable to mean that per cent non-farm population (Assessment) is more directly distributed in accordance with acreages of the small fruits variable than are some of the other variables. The overall effect on all variables for 1966 is to generally increase the correlation coefficient suggesting a more uniform surface of per cent non-farm population (Assessment) than for per cent non-farm population (Census). In other words, some of the more irregular nodal disturbances have been removed when parts of the village, town and city fringe populations are excluded as defined for the assessment roll data set.

Turning back to the results using per cent non-farm population (Census), note that all census data are reported back to the headquarters of the farm. Thus, if a farmer operates land outside the township in which his farmstead is located areal discrepancies result. Statistics reported for a township may, therefore, be greater or less than the real totals contained within a township's area and since population is reported at location of residence, areal discrepancies can also occur when only census data are used.

Of the six variables not previously tested in the Hamilton-London area, none was significant in 1941 and only per cent full or part tenant farms of total farms was significant in 1966. This variable, like the rental land variable, has a greatly increased correlation since 1941. These two variables are interrelated (correlation in 1966 of 0.929) and appear as the best variables measuring urban impact though the unlikely possibility exists that farmers want to rent land but can only find such land to rent in areas of greater non-farm population.

Four postulated hypotheses of urban impact on agricultural elements are thus supported for township areal units. The per cent rented land of farm land does increase as per cent non-farm population increases (1966, 0.736). The per cent full or part tenant farms of total farms increases as per cent non-farm population increases, (1966, 0.696). The value of farm land and buildings per acre of improved land increases as per cent non-farm population increases (1966, 0.807). Also, the acres of improved land per farm tend to decrease as per cent non-farm population increases (1966, −0.470).

A Factor Analytic Approach

Having accepted the areal discrepancies that occur when the two available but different data sets are combined it appeared useful to try a factor analysis of the 12 variables already used in the correlation analysis. Five additional variables are added from the assessment roll data set; these are the last five listed on Table 14. They were selected because of their importance in the *urban fringe* and *urban shadow* factors derived in the analysis of the land space matrix.

The factor analysis then is based on 17 variables in both 1941 and 1966; because of missing assessment roll data, only 27 townships are used in 1941 as compared with 30 for 1966. In interpreting the factors, the operating rules of including significant variable loadings of 0.50 or −0.50 and over and including only factors having four or more variables loading significantly, are again used. The 1966 results are first discussed and then 1941 results are noted and used to compare cross-sectional change.

Urbanization-Agriculture Factor Analysis Results, 1966

Five factors explained 91.1 per cent of the total variance. However, only three factors together explaining 71.6 per cent of the variance had four variables loading significantly. These factors have been named *Urbanization Impact, Urbanization and Special Crops,* and *General Agricultural Land Use.* The two factors not interpreted each have two variables loading significantly and positively. The one combines per cent farm land assessment of farm assessment with per cent non-farm assessment of total assessment; the other combines per cent other improved land of improved land with per cent other unimproved land of farm land. Both these factors thus suggest an urban shadow relationship in that some townships where non-farm assessment is higher also have a higher proportion of farm land of farm assessment, i.e., less in farm buildings and the other improved land (idle land, sod farms) occurs more in townships with more unimproved land.

TABLE 14

URBANIZATION-AGRICULTURE VARIABLES[a] USED IN FACTOR ANALYSIS
1941 AND 1966

	Township Means[b]	
	1941	1966
1. Per cent population non-farm (census)	30.4	52.9
2. Per cent full or part tenant farms of total farms	17.9	21.9
3. Per cent rented land of farm land	13.5	16.1
4. Per cent improved land of farm land	81.8	82.7
5. Acres of improved land per farm	87.8	109.2
6. Per cent field crops not reported plus potatoes of improved land	2.8	2.8
7. Per cent other improved land of improved land	29.4	28.6
8. Per cent woodland of farm land	8.6	8.2
9. Per cent other unimproved land of farm land	9.6	9.0
10. Per cent small fruits, vegetables and nurseries of improved land	0.6	0.8
11. Dollar value of farm land and buildings per acre of improved land	80.4	399.7
12. Per cent population non-farm (assessment)	12.4	46.9
13. Per cent farm land assessment of farm assessment	71.7	61.9
14. Per cent non-farm assessment of total assessment	4.4	36.6
15. Per cent non-farm owned non-resident land of total land	2.7	12.3
16. Per cent non-farm owned landholding land of total land	3.8	16.3
17. Per cent non-farm owned residential land of total land	0.3	1.5

[a] In the multiple correlation analysis, variables 2 to 10 are treated successively as the dependent variable and variables 11 to 16 are used as independent variables.

[b] Based on 30 townships in 1966 and 27 townships in 1941.

TABLE 15

URBANIZATION-AGRICULTURE FACTOR ANALYSIS RESULTS, 1966

FACTOR 1

URBANIZATION IMPACT

34.3%, 9 variables

Variable	Loading
Per cent population non-farm (census)	0.86
Per cent full or part tenant farms of total farms	0.93
Per cent rented land of farm land	0.92
Value of farm land and buildings per acre of improved land	0.72
Per cent population non-farm (assessment)	0.82
Per cent non-farm assessment of total assessment	0.54
Per cent non-farm owned non-resident land of total land	0.81
Per cent non-farm owned landholding of total land	0.82
Per cent non-farm owned residential of total land	0.51

FACTOR 2

URBANIZATION AND SPECIAL CROPS

19.6%, 5 variables

Variable	Loading
Improved acres per farm	0.62
Per cent field crops not reported plus potatoes of improved land	−0.96
Value of farm land and buildings per acre improved land	−0.54
Per cent small fruits, vegetables, nurseries of improved land	−0.97
Per cent non-farm owned residential of total land	−0.74

FACTOR 3

GENERAL AGRICULTURAL LAND USE

17.7%, 4 variables

Variable	Loading
Per cent improved land of farm land	0.89
Improved acres per farm	0.55
Per cent woodland of farm land	−0.95
Per cent other unimproved land of farm land	−0.67

Factor 1, Urbanization Impact: Variables loading significantly on this factor and the other factors interpreted are given on Table 15. This factor explains over a third of the total variance and verifies the main facets of the urbanization impact. Clustering together to make up this factor are the prominent variables from the *urban fringe* and *urban shadow* factors of the land space matrix analysis and three of the four agricultural elements identified as being most affected by expanding urbanization in the simple linear correlation analysis. Thus, non-farm population, non-farm owned residential land, and non-farm assessment from the *urban fringe* factor, non-farm owned non-resident land and non-farm owned landholding from the *urban shadow* factor combine with the agricultural elements of tenant or part tenant farms, rented land, and value of farm land and buildings. Since all these variables load positively, they all increase together. Tentatively interpreting in a process sense, this factor implies that land speculation suggested by increased amounts of the landholding and non-resident land ownership categories lead to higher land values and more rented farm land, and are associated areally with non-farm population which is, of course, closely related to residential land ownership.

Factor 2, Urbanization and Special Crops: This bipolar factor accounts for about one-fifth of the total variance. Loading significantly negatively are the census variables measuring special crops and value of land and buildings. Also with a negative sign is the assessment roll variable of non-farm owned residential land. Loading positively are improved acres per farm. The interpretation then, is that increasing amounts of non-farm residential land ownership occurs in conjunction with increasing acreages of special crops, and that acres of improved land per farm are less but the value of land and buildings per improved acre is greater. One of the hypothesis not supported significantly in 1966 for the correlation analysis had been that more non-farm population and more acreages of specialized crops should go together. From this factor, it appears that non-farm residential land acreage rather than non-farm population is the variable needed to support the hypothesis postulated for the simple correlation analysis.

Factor 3, General Agricultural Land Use: Explaining 18 per cent of the total variance between townships is another bipolar factor. The logical interpretation here is that farms with more improved acres and with a higher per cent of the farm acreage being improved will especially have less land in woodland (loading - 0.95) and in other unimproved land. Knowledge of the agricultural scene of the Toronto-Stratford area suggests that intensive farming is generally the case, except in a few townships, and most bona fide farms are almost completely in improved land. The 30 townships average in 1966 shows 83 per cent of farm land improved, eight per cent woodland, and nine per cent other unimproved land.

Urbanization-Agriculture Factor Analysis Results, 1941

Only 78.4 per cent of the total variance is explained by the factors extracted using an eigen value cut off of 1.0. Evidently, the urban impact on agriculture as measured by the variables used was less clear cut in 1941. Moreover, no one factor is dominant as in 1966 since each factor accounts for roughly one-quarter of the variance explained (see Table 16). In addition, only two of the farm factors have urbanization and agricultural variables loading together. These are the *Urbanization and Special Crops* factor, one of

TABLE 16

URBANIZATION-AGRICULTURE FACTOR ANALYSIS RESULTS, 1941

FACTOR 1

URBANIZATION AND SPECIAL CROPS

21.6%, 6 variables

Variable	Loading
Per cent population non-farm (census)	0.64
Improved acres per farm	−0.82
Per cent other improved of improved land	−0.52
Per cent small fruits, vegetables, nurseries of improved land	0.86
Value of farm land and buildings per acre of improved land	0.88
Per cent non-farm owned residential of total land	0.51

FACTOR 2

URBAN FRINGE-URBAN SHADOW

20.0%, 4 variables

Variable	Loading
Per cent population non-farm (assessment)	0.67
Per cent non-farm assessment of total assessment	0.83
Per cent non-farm owned non-resident land of total land	0.86
Per cent non-farm owned landholding of total land	0.87

FACTOR 3

GENERAL AGRICULTURAL LAND USE

19.6%, 4 variables

Variable	Loading
Per cent improved land of farm land	0.95
Per cent field crops not reported plus potatoes of improved land	−0.74
Per cent woodland of farm land	−0.83
Per cent other unimproved of farm land	−0.84

FACTOR 4

EXTENSIVE (MARGINAL FARMING)

17.2%, 4 variables

Variable	Loading
Per cent full or part tenant farms of total farms	0.87
Per cent rented land of farm land	0.80
Per cent farm land assessment	0.62
Per cent non-farm owned residential of total land	−0.52

the two factors comparable to a 1966 factor, and *Extensive (Marginal) Farming.* The other two factors are named *Urban Fringe-Urban Shadow* and *General Agricultural Land Use,* the other factor comparable to a 1966 factor.

The overall conclusion from this factor analysis as for the land space matrix analysis is that urban impact on agriculture in 1941 was negligible but that by 1966 the dynamic effects of urbanization were clearly established. How the processes work, is, of course, not made clear by the factor analysis technique, which only provides descriptive summary results from which hypothesis can be generated. If better understanding of the effect of urbanization on agriculture is expected, then detailed case studies on the hypothesis raised here and other hypotheses is mandatory.

Factor 1, Urbanization and Special Crops: This bipolar factor is similar to Factor 2 of the 1966 analysis and explains approximately the same amount of variance. Four of the six variables loading significantly also did so in 1966. These are the agricultural variables of improved acres per farm and per cent small fruits, etc., value of farm land and buildings and the urbanization variable of non-farm owned residential land. Additionally, per cent population non-farm (census) loads positively and per cent other improved land of improved land loads negatively. Thus, higher capitalization values are associated directly with greater acreages in small fruits, etc., with more non-farm owned residential land and more non-farm population (census) and inversely with improved acreage per farm and per cent other improved of improved land. The addition of this last variable poses the tentative notion that other improved land (farmsteads, idle land, sod farms) was usually not found on farms growing the specialized crops in 1941. If so, then special crops, which accounted for only 0.6 per cent (townships average) of improved land, were usually grown in areas of full-scale farming. Specific investigation would be needed to substantiate this suggestion.

Factor 2, Urban Fringe-Urban Shadow: This factor consists only of urbanization variables. Two of the variables loading significantly, per cent population non-farm (assessment) and per cent non-farm assessment of total assessment, were prominent variables in the *Urban Fringe* factor of the land space matrix analysis. The other two variables loading significantly, per cent non-farm owned non-resident and landholding land were prominent variables in the *Urban Shadow* factor of the land space matrix analysis. A process-oriented interpretation of this factor suggests that the urban fringe and urban shadow effects were not really affecting agriculture in 1941, at least for the township units providing the observation units for this analysis.

Factor 3, General Agricultural Land Use: This bipolar factor consists only of agricultural variables and is similar to factor 3, 1966. The bipolar relations of improved and unimproved land are again noted. More difficult to interpret is the negative loading of per cent field crops not reported plus potatoes of improved land – the alternative measure of special crops. It appears that in 1941 at least some special crops tended to be grown on farms with considerable land in woodland and other unimproved farm land while others did not (Factor 2). Note that interpretations, such as those made above, fall under the spatial data problem known as ecological correlation (Robinson, 1950, Duncan and Davis, 1953, Goodman, 1959, Duncan, Cuzzort and Duncan, 1961). The nature of this problem is that inferences about individuals cannot safely be made from ecological correlations based on manipulation of areal unit date.

However, muck and silt soils used for some of these special crops are often associated with swampland areas. As is often the case in the application of factor analysis, tentative hypotheses are suggested which need detailed investigation to verify or reject.

Factor 4, Extensive (Marginal) Farming: This factor has tentatively been subtitled marginal farming because the three variables loading positively all indicate, at least in 1941, minimal farming operations. Farm land accounts for a higher proportion of total farm assessment suggesting minimal investment in buildings; more of the farms are full or part tenant farms; more of the farm land is rented. Inversely related is the per cent of non-farm owned residential land. It appears, then, that, for 1941, this factor points at townships with little non-farm development and with considerable marginal farm land. Factor scores, which would permit verifying the above hypothesis, unfortunately were not produced in this factor analysis because of a need to reduce the computer time used in this project.

A Multiple Correlation Approach

The Independent Variables

In an attempt to add further explanation to the urbanization-agriculture relationship, a series of multiple correlations was run using the B.M.D. Stepwise Multiple Regression Program. Each of the variables (selected agricultural elements) numbered 1 to 9, listed on Table 17, was taken as the dependent variable and variables 10 to 15 were, in each case, used as the independent or "explanation" variables. This technique will help show how the urbanization variables together affect the individual agricultural elements.

Four of the independent variables are from the assessment rolls data set and were selected on the basis that the dynamic forces affecting agriculture in an area of expanding urbanization such as the Toronto-Stratford or Hamilton-London corridor areas emanate from the urban areas. The non-farm population and assessment variables represent the *Urban Fringe Factor* from the land space matrix analysis. The non-farm owned non-resident and landholding variables represent the *Urban Shadow Factor* from the land space matrix analysis.

The remaining two independent variables less directly measure urban impact on agriculture. The land value variable was shown to be significantly related to non-farm population and presumably affects the selected agricultural elements in ways similar to that of the other four independent variables measuring urbanization. For this variable, then, the assumption is made that it is the value which tends to structure the agricultural element. This argument is similar to the classic urban economics "chicken and egg" problem of whether land use activity determines land value or whether land value determines land use activity. That cumulative interactions exist seems to be the best answer. The farm land assessment independent variable should theoretically vary directly with the value of farm land and buildings variable (in fact the value is 0.778). That is, where capitalization values are higher, the per cent farm land assessment of total farm assessment tends to be lower. This variable was selected as the variable from the assessment roll data set most comparable to value of farm land and buildings. It also provides an indirect measure of the independent value of land for 1941 and 1966 that is not available from the census capitalization variable.

Urbanization-Agriculture Multiple Correlation Results, 1966

In 1966, the selected independent variables measuring urbanization showed significant results at the one per cent probability level for four agricultural elements (see Table 17). Two of these, per cent full or part tenant farms and per cent rented land, were identified as being significantly related in the simple correlation with per cent population non-farm. Here, however, the first variables entering the equations are per cent landholding and per cent non-resident land respectively. The added variables in the equation increase the multiple correlation only 0.089 and 0.076. Thus, the two prominent urban shadow variables, landholding and non-resident owned land, show strong relationships to per cent tenant or part tenant farms and to rented farm land. Also influenced strongly by the landholding variable is the per cent of other unimproved land of farm land with the multiple correlation being 0.727 and the simple correlation being 0.668. Hence, the independent variables, other than landholding, add only 0.059 to the coefficient. The fourth variable above the one per cent probability level with a multiple correlation of 0.682 per cent, small fruits, etc. is influenced most strongly by value of farm land and buildings, supporting results obtained on the factor analysis.

Three other dependent variables have multiple correlations significant above the five per cent probability level. One is acres of improved land per farm, which, like per cent small fruits, etc., is related to value of farm land and buildings. Another is per cent improved land of farm land with the first entered variable being per cent non-farm population. The third is per cent field crops not reported. At the cut-off point for the five per cent probability level, over one-third of the variance is still explained, i.e. R^2 is 0.377 for the last variable.

The remaining two variables tested are significant at the 10 per cent probability level. Possibly, if data were available for smaller, more equal area areal units such as township blocks, these two elements might show higher correlations.

These multiple correlation results further support the findings earlier established by the simple correlations and factor analysis approaches. Certainly by 1966, expanding urbanization is associated with most agricultural elements, though only per cent full or part tenant farms and per cent rented land have two-thirds of their variance explained. Analysis of the residuals not undertaken here could also add further understanding. One area not investigated here is the association between livestock and proportions in different crops. Probably in 1966 a number of significant relations with urbanization could also be uncovered.

Urbanization-Agriculture Multiple Correlation Results, 1941

Again the results support those noted earlier in this section and in the land space matrix analysis: the effect of expanding urbanization was still minimal in 1941. Only the correlations for the interrelated agricultural elements of acres of improved land per farm and the per cent small fruits, etc. are significant. And both of these are strongly influenced by the one independent variable used from the census data set—value of farm land and buildings. These two variables remained significant in 1966 but with a declining multiple coefficient of correlation.

TABLE 17

URBANIZATION-AGRICULTURE MULTIPLE CORRELATION RESULTS
1941 AND 1966

Independent Variables

1. Dollar value of farm land and buildings per acre of improved land
2. Per cent population non-farm (assessment)
3. Per cent farm land assessment of farm assessment
4. Per cent non-farm assessment of total assessment
5. Per cent non-farm owned non-resident land of total land
6. Per cent non-farm owned landholding land of total land

Dependent Variable[a]	R		R^2		R of independent Variable Entering First	
	1941	1966	1941	1966	1941	1966
1. Per cent full or part tenant farms of total farms	0.444	0.806**	0.197	0.650	3[b] 0.314	6 0.717**
2. Per cent rented land of farm land	0.424	0.883**	0.180	0.779	3 0.292	5 0.807**
3. Per cent improved land of farm land	0.373	0.633*	0.139	0.400	2 0.324	6 0.530**
4. Acres of improved land per farm	0.809**	0.622*	0.654	0.387	1 0.728**	1 0.594**
5. Per cent field crops not reported plus potatoes of improved land	0.377	0.614*	0.142	0.377	3 0.217	1 0.565**
6. Per cent other improved land of improved land	0.638	0.583	0.407	0.339	3 0.438*	5 0.404*
7. Per cent woodland of farm land	0.403	0.474	0.162	0.224	3 0.298	2 0.244
8. Per cent other unimproved land of farm land	0.481	0.727**	0.231	0.529	5 0.373	6 0.668**
9. Per cent small fruits, vegetables and nurseries of improved land	0.867**	0.682**	0.752	0.465	1 0.841**	1 0.641**

[a] Based on 30 townships in 1966 and 27 townships in 1941; hence the magnitude needed in the R value for significance differs between 1966 and 1941.

[b] Numbers represent the independent variables as listed above.

**Significant at the 0.01 probability level, F test

* Significant at the 0.05 probability level, F test.

Also worth noting from Table 17, is the fact that the independent variable per cent farm land assessment of farm assessment entered first into the equation for five of the seven variables whose multiple correlation was not significant. Since the simple entering correlation was positive, it means that as farm land accounts for more of total farm assessment, more tenant farms, more rented land, more field crops not reported, more other improved land and more woodland occur. These results appear comparable to *The General Agricultural Land Use* and *The Extensive (Marginal) Farming Factors.*

Population Growth and Loss of Improved Farm Land

One other aspect of expanding urbanization and agriculture is introduced here. That aspect is the loss of agricultural land which is usually stressed as a summation effect of urbanization on agriculture. (Bogue, 1956, Higbee, 1960, Crerar, 1962A, Hind-Smith, 1962). Statistics derived from the Census of Canada on the loss of improved land are mainly used for 1941 and 1966 and are also compared with results for the Hamilton to London area for 1941 to 1961 change. Some marginal land has reverted from agricultural use mostly between 1941 and 1951 (Table 18). Such land, after 1951, reverted primarily directly into the non-farm owned residential or landholding categories. Such land abandonment from agricultural use (or converted to non-farm uses) was most prominent in Caledon, Albion and Puslinch townships.

TABLE 18

POPULATION GROWTH AND LOSS OF IMPROVED FARM LAND
TORONTO TO STRATFORD CORRIDOR AREA

Year	Total Population	Acres[a] Improved Farm Land	Time Period	Population Change	Acres Improved Farm Land Lost	Acres Improved Farm Land Lost per 1,000 Population Added
1941	254,565	1,263,110	1941-51	72,674	62,673	863
1951	327,239	1,200,437	1951-56	90,309	24,369	267
1956	417,548	1,176,068	1956-61	108,684	48,767	450
1961	526,232	1,127,301	1961-66	147,910	21,371	144
1966	674,142	1,105,930	1951-61	198,993	73,136	367
			1941-61	271,667	135,809	501
			1941-66	419,577	157,180	375
			1951-66	346,903	94,507	274

[a] Definitions of a census farm were the same 1941, 1961, 1966 as a unit of 1 acre or more and sales of agricultural products of $50 or more in the 12-month period prior to the census. In 1951 and 1956 the definition was less restrictive when the definition was 3 acres or more *or* 1 to 3 acres with sales of $250 or more in the 12-month period prior to the census.

Acres of improved farm land lost per 1,000 population increase is used as an index measure of urbanization conversion of agricultural land. Total population growth may be used because farm population 1941 to 1966 declined in all but five peripheral townships which together showed a negligible farm population increase of 225 people in total.

Loss of Improved Farm Land

The net loss of improved farm land in the Toronto-Stratford Corridor area 1941 to 1966 amounted to 157,180 acres (246 sq. miles) or approximately 13 per cent of the improved farm land area of 1941 (1,263,110 acres or 1,974 sq. miles). This net loss figure, however, hides a gain of 5,500 acres in Woolwich, Downie, Easthope North and Mornington townships.

Comparative statistics for the 1941-61 period show the improved farm land loss to be 135,809 acres or 212 square miles, representing 11 per cent of the improved farm land area of 1941. Thus, in the 1961-66 time period, only 34 square miles of improved farm land were lost. Definitions of census farms for these three years were the same.

When these results are compared to those obtained in the Hamilton-London area 1941-1961 (1,005,000 acres of improved land in 1941) the rate of loss is more than double at 11 per cent to five per cent (Russwurm, 1964). However, in the Toronto-Stratford area, 40 per cent of this land was lost between 1941 and 1951 (63,000 acres) possibly half of which was probably marginal farm land abandoned from agriculture. Evidence for this statement comes from checking the seven townships which lost over 10,000 acres between 1941 and 1966 (Albion, Caledon, Toronto, Burlington, Oakville, Waterloo, Puslinch). Between 1941 and 1951, 63,000 acres of improved farm land were lost. Of this total, approximately one-quarter (15,600 acres) was lost (abandoned?) in Albion and Caledon townships. Also, these two townships each lost over 50 per cent of their total loss 1941-66 between 1941 and 1951; most other townships lost less than 25 per cent of total loss 1941-66. During the 1941-51 period, these two townships and their one incorporated village, Bolton, added only 600 people—hence, the conclusion that the 1941 to 1951 loss of improved farm land included reversion of considerable acreages to the unimproved category. Note that the reduction should be on the conservative side because of the more liberal definition of a census farm in 1951.

Of the loss of 246 square miles of improved farm land 1941 to 1966, 150 square miles or 77 per cent occurred in the eight townships bordering Metro Toronto, the Kitchener Metropolitan area, Oakville, Burlington, and Guelph. Similar results were noted in the Hamilton-London area 1941-61, when 76 per cent of the loss of improved farm land occurred in the six townships bordering London, Brantford and Hamilton (Russwurm 1967).

Population Growth and the Loss of Improved Farm Land

For the study area as a whole 1941-66, 375 acres of improved farm land were lost for each 1,000 people added to the population (Table 18). This loss is considerably greater than the 192 acres recorded for the Hamilton-London area 1941-1961 (Russwurm, 1967). However, between 1961 and 1966 the loss in the Toronto-Stratford area was only 144 acres per 1,000 population increase. As noted above, the Toronto-Stratford loss per 1,000 population increase is inflated by abandonment of land for agriculture in the rough morainal lands on the backslope of the Niagara Escarpment. When the losses of improved land per 1,000 population increase for the different time periods are compared, the trend is to a lesser loss over

time. Note that the high rate of loss 1956-61 resulted partly from the more restrictive definition of a census farm again applied in 1961 as it had been in 1941.

Further indicating that the abandonment of improved farm land must be considered in the Toronto to Stratford area, are the following statistics for the townships bordering the major urban centres. In all but one case, the loss of improved land per 1,000 population increase in the townships bordering the cities 1941-1966 is less than for the study area as a whole. The results are as follows: Metro Toronto, 302 acres; Kitchener Metropolitan Area, 204 acres; Oakville, 310 acres; Burlington, 335 acres; Guelph, 492 acres. However, note that for Guelph most of the city's development, until recently, has taken place in Guelph Township only, whereas, the 492 acres per 1,000 population increase is based on both Guelph and Puslinch townships with distinctly different losses, respectively, of 264 acres and 1,714 acres. The Puslinch figure reflects some abandonment of marginal land. Final evidence that abandonment of marginal land is worth noting is seen in the statistics for Albion and Caledon townships, including Bolton; from 1941 to 1966 5,940 acres of improved land were lost per 1,000 population increase. The above statistics also support previous findings that loss of agricultural land is greater in relatively poorer farming areas—e.g., Burlington compared with the Kitchener Metropolitan area (Hind-Smith, 1962, Russwurm, 1961).

More detailed study would be useful on the relationship between the loss of improved farm land and urban development forces. For example, empirical evidence has shown that the larger the city, the lesser the acreage used per person. Usually, the theoretical reasons advanced for such increased efficiency in land use come from the field of urban land economics. As demand for land increases, it becomes more costly and, consequently, more efficient use is made of land. Also, urban flows increase in magnitude and variety with potential congestion then contributing to more efficient, less consumptive use of land.

A similar hypothesis should hold for the urban fringe areas of cities. It would state that the larger the city, proportionately the lesser the area of land in urban fringe and urban shadow uses. The declining acres of improved land (144 acres) used per 1,000 population increase in 1961 to 1966 could be construed as evidence that increased efficiency in the use of land for urban purposes is occurring in the Toronto to Stratford area. The unverified assumption often popularly stated is the opposite: the larger the city, the greater the urban sprawl impact. This hypothesis needs careful testing.

Assuming a loss of 150 acres of improved farm land per 1,000 population increase (the 1961-66 figure), the study area would lose 158 square miles of its improved farm land in doubling its 1961 census population of 674,000. Or, if a figure closer to the 1951-1966 loss (274 acres) were used, say, 300 acres per 1,000 population increase, the acreage lost would double to 316 square miles. Since the total area of improved farm land in 1966 was 1,656 square miles, the loss of improved farm land using the figures of 150 and 300 per 1,000 population would be nine per cent and 18 per cent of the 1966 acreage. As earlier noted for the Hamilton to London area, about five-sixths of the present acreage of improved land in the study area would still be in agricultural production whenever the population doubled.

This conclusion is contradictory to Crerar's provocative statement. He postulated that by the year 2000 no significant agricultural production would occur in the study area which would be part of a large, more or less, continuous urban agglomeration (Crerar, 1962B).

Over the 25-year period investigated in this simple cross-sectional analysis, the expansion of urbanization has been related to certain selected agricultural elements, especially amount of rented land, proportion of farms, part or full tenant, and value of farm land and buildings. The factor analysis results indicated increasing influences of urbanization measures on agricultural elements. No appreciable amount of improved farm land has, however, been lost during the expansion of urbanization across land space. The trend noted in the study area does not support the notion that larger scale, more intensive urbanization will accelerate the loss of improved farm land per 1,000 population increase. Increasingly, the improvement and increasing public support of regional planning along with the pressures of urban land economics is leading to more efficient land use. Based on the evidence noted above, and the general prosperity of farming operations in most of the study area, it is realistic to expect that 90 per cent of the improved land acreage will still be in agricultural use by the time the population of the study area doubles.

PART V

FUNCTIONAL ANALYSIS OF VILLAGES

In the two previous parts of this report, the urbanization impact on the land space matrix and on agriculture as the major user of that matrix was assessed. In this part of the locational sub-system of the urban system, nodes which arise out of activities carried on in the land space and which in turn influence and help organize those activities are analyzed.

The data source for the functions of villages and hamlets was *The Dun and Bradstreet Reference Books, 1941 and 1966.* This data source has been used previously in analysing functions of settlements (Borchert and Adams, 1963, Hodge, 1966). For reference purposes, Appendix C has been included in which the Dun and Bradstreet data source is evaluated.

The smallest nodes reported on in detail here are the villages, defined for this study as places having at least three functional units in both 1941 and 1966. The reason for choosing three functional units as a minimum for a commercial node is that at least one additional function to the recurring general store and service station garage would be present. Smaller nodes, called hamlets, can also be identified as places having one to two functional units. Such hamlets in this study are not analysed separately but instead are included as part of the land space matrix. For the record, however, 56 such hamlets were identified for 1941 of which only 29 retained at least one functional unit by 1966. Of these 29 still existing in 1966, 15 had declined in the number of functional units, 10 had the same number of functional units and only 4 had increased in functional units. Note that not all places recorded in 1941 in *The Dun and Bradstreet Reference Book* and which had disappeared by 1966 were field checked to verify actual loss of the functional unit; Dun and Bradstreet do not always retain declining or small establishments in their listings.

These minimal nodes or hamlets thus do show a distinct pattern of decline and where urbanization forces do not promote such nodes to the village level, actual absorption into the land space matrix will largely be the result. Similar, though weaker evidence, has been noted by Hodge in Saskatchewan, Prince Edward Island, and Eastern Ontario (Hodge, 1965, Hodge and Paris, 1966, Hodge, 1966). In Southwestern Ontario, comparative results are available for the Hamilton to London Corridor and indicate a similar though less severe pattern of decline (Russwurm, 1964).

In the following pages, two descriptive analytical approaches are used: (1) the functional structure and change of the villages is described using simple measures and factor analytic techniques for both 1941 and 1966; and (2) a functional grouping of villages using a grouping routine is developed and described.

Functional Structure and Change

The basic data used to describe the functional structure of the villages are classified for 1966 in *The Dun and Bradstreet Reference Book* according to *The United States Standard Industrial Classification Manual.* For 1941, however, the village functions are

only verbally described and thus had to be converted into the Standard Industrial Classification Codes. Some of the rules used and problems encountered for this conversion are noted in Appendix C.

In order to clarify the analysis, some of the three and four digit S.I.C. functions have been combined into two or three digit groups. This was done to provide more meaningful groups out of functions that did not occur frequently. Nine,three and four digit S.I.C. functions of a central place nature which had occurred in over one-third of the villages in 1941 were retained separately (see Table 19). It is these nine most frequently recurring functions which still tend to typify the villages. The term functional classes is used for the functional groups for all of the two, three and four digit S.I.C. classes.

Overall Functional Change

General functional characteristics of the villages are presented on Table 19 along with populations. All villages are identified on the location map, Figure 1. Unlike the situation for the hamlets, the overall pattern is one of functional increase. For all 75 villages, 1,168 functional units were counted in 1966, compared with 1,024 in 1941—a 14 per cent increase. This increase will be a conservative estimate because wherever establishments descriptively appeared to have more than one function in the *The Dun and Bradstreet Reference Book, 1941* they were counted (see Appendix C), resulting in some overcount for 1941 in comparison with 1966. In 1966, a more rigorous definition of functional units holds. As used here, the term functional unit refers to an individual occurrence of a function.

Functional units were tabulated for both central place functions (wholesale and retail trade and services) and non-central place functions (manufacturing, construction, transportation and communications) for the 75 villages. A complete listing of 2, 3, and 4 digit S.I.C. functional classes for all villages is included as Appendix D.

While for total functional units an increase occurred, central place functional units actually declined eight per cent from a total of 1,024 in 1941 to 905 in 1966. Given the data conversion problem involved in using *The Dun and Bradstreet Reference Book, 1941*, this result should probably be interpreted to indicate that central place functional units are just holding their own despite significant population increases in almost all villages.

Thus, the increase in functional units is completely attributable to the non-central place functional units. An overall increase of 213 non-central place functional units occurred (119 to 332 in total). Consequently, non-central place functional units accounted for 29 per cent of all functional units of the villages in 1966 as compared with only 12 per cent in 1941. From a process standpoint, I interpret this result to indicate that villages are increasingly being incorporated into the total urban system and that interdependencies between the villages and the other nodes of the urban system are increasing.

In so far as the actual functional change, village by village, is concerned, it will reflect the overall functional change just noted. A balanced situation exists for total

TABLE 19

FUNCTIONAL CHARACTERISTICS OF VILLAGES, 1941 AND 1966

Village	Population[a] 1941	Population[a] 1966	% Change 1941-1966	All Functional Units 1941	All Functional Units 1966	Central Place Functional Units 1941	Central Place Functional Units 1966	Per Cent Central Place Functional Units 1941	Per Cent Central Place Functional Units 1966
Aberfoyle	79	179	126.6	6	4	4	4	67	100
Alma	129	205	58.9	9	14	9	13	100	93
Alton	303	512	69.0	18	12	16	5	89	42
Ayr	761[c]	1,134[c]	49.0	44	39	36	31	82	79
Baden	589	980	66.4	27	25	22	15	74	60
Ballinafad	60	122	103.3	4	3	4	3	100	100
Belwood	139	132	−5.0	5	4	4	4	80	100
Blair	137	219	59.9	4	5	3	4	75	80
Bloomingdale	238	304	127.7	4	4	4	3	100	75
Bolton	577[c]	2,344[c]	306.2	40	70	34	41	85	59
Branchton	109	188	72.5	3	6	3	4	100	67
Breslau	217	787	262.7	11	21	10	10	91	48
Bridgeport	400[b]	2,111	427.8	10	25	8	12	80	48
Caledon	200[b]	380	90.0	10	19	10	11	100	58
Caledon East	300[b]	673[c]	124.3	22	15	21	13	95	87
Campbellville	200[b]	275[c]	37.5	18	16	15	11	83	69
Carlisle	147	526	257.8	6	6	6	6	100	100
Cheltenham	137	155	13.1	4	4	4	3	100	75
Conestogo	247	513	107.7	13	10	11	6	85	60
Doon	212	436	105.7	4	7	4	4	100	57
Drayton	504[c]	677[c]	34.3	36	30	32	24	89	80
Eden Mills	108	208	92.6	4	3	4	2	100	67
Elora	1,247[c]	1,644[c]	31.8	43	46	38	30	88	65
Erin	499[c]	1,195[c]	139.5	38	46	35	39	92	85
Floradale	251	306	21.9	7	8	6	5	86	63
Gadshill	68	116	70.6	4	3	4	3	100	100
Glen Allan	108	107	−0.1	6	4	6	4	100	100
Glen Williams	402	824	104.9	7	6	2	3	29	50
Hawkesville	109	257	135.8	6	9	6	5	100	56
Heidelberg	170	438	157.6	5	5	5	3	100	60
Hillsburgh	355	491	38.3	27	22	25	16	93	73
Huttonsville	192	366	90.6	4	5	3	4	75	80
Inglewood	304	475	56.3	14	13	12	10	86	77
Limehouse	129	289	124.0	3	4	2	3	67	75
Linwood	237	450	89.9	19	21	18	12	95	57
Malton	232	4,304	855.2	18	93	17	60	94	65
Marsville	41	60	46.3	4	3	4	3	100	100
Maryhill	141	266	88.7	7	7	7	5	100	71
Meadowvale	167	354[c]	112.0	3	4	3	3	100	75
Millbank	245	264	7.8	11	11	10	8	91	73
Milverton	1,015[c]	1,122[c]	10.5	47	32	41	24	87	75

TABLE 19

FUNCTIONAL CHARACTERISTICS OF VILLAGES, 1941 AND 1966 *(continued)*

Village	Population[a]		% Change	All Functional Units		Central Place Functional Units		Per Cent Central Place Functional Units	
	1941	1966	1941-1966	1941	1966	1941	1966	1941	1966
Mono Mills	70	110	57.1	3	3	3	3	100	100
Mono Road	75	136	81.3	4	3	4	3	100	100
Moorefield	224	325	45.1	20	19	20	17	100	89
Morriston	172	244	41.9	7	6	6	5	86	83
New Dundee	333	613	84.1	22	17	19	13	86	76
New Hamburg	1,402[c]	2,438[c]	73.9	58	61	47	46	81	75
Newton	119	149	25.2	5	6	4	3	80	50
Norval	114	467	309.6	9	18	9	12	100	67
Orton	59	69	16.9	6	3	5	3	83	100
Ospringe	45	101	124.4	3	4	3	4	100	100
Palermo	70	256	265.7	4	4	4	4	100	100
Palgrave	124	231	86.3	8	8	8	6	100	75
Petersburg	112	196	75.0	12	16	10	10	83	63
Puslinch	20	45	125.0	3	7	3	6	100	86
Rockwood	574	894	55.7	22	32	20	26	91	81
Rostock	134	108	−19.4	8	7	5	6	63	86
Rothsay	81	94	16.0	3	4	3	4	100	100
St. Agatha	133	562	322.6	5	10	3	8	60	80
St. Clements	252	656	160.3	13	9	10	5	77	56
St. Jacobs	663	1,238	86.7	34	35	29	21	85	60
St. Pauls	70	68	−2.9	5	4	5	2	100	50
Salem	443	581	31.2	6	4	6	4	100	100
Sandhill	48	131	172.9	3	3	3	3	100	100
Sebringville	288	511	77.4	19	20	19	15	100	75
Shakespeare	211	344	63.0	12	11	11	8	92	73
Snelgrove	73	219	200.0	5	3	5	2	100	67
Tavistock	1,066[c]	1,294[c]	21.4	64	59	57	43	89	73
Terra Cotta	39	189	384.6	3	3	3	3	100	100
Victoria	56	96	71.4	3	4	3	4	100	100
Wallenstein	58	221	281.0	33	9	2	7	67	78
Waterdown	910[c]	1,935[c]	112.6	31	57	24	43	77	75
Wellesley	396	659[c]	66.4	40	29	39	25	98	86
West Montrose	80	86	7.5	3	3	3	3	100	100
Winterbourne	117	263	124.8	3	3	3	3	100	100
TOTALS	19,995	41,917	109.6	1,024	1,168	905	836	88	71

[a] Population from assessment rolls unless otherwise noted.

[b] Population from the *Dun and Bradstreet Reference Book.*

[c] Population from *The Census of Canada.*

functional units in that 32 villages increased their number, 32 declined, and 11 retained the same number of functional units from 1941 to 1966. The lessened dependence of the villages generally on central place functions is evident. From 1941 to 1966, 41 villages suffered a decline in the number of central place functional units while another 11 maintained their 1941 total. Thus, only 23 villages actually increased their central place functional units. The enveloping effect of expanding urbanization is further emphasized when noting that it is the larger villages which show declines in central place functions despite population growth. All 31 villages which had 10 or more functional units in 1941 showed a decline in the per cent of total functional units accounted for by central place functions. Altogether 49 of the 75 villages showed such a decline (see Table 20).

Population Growth and Functional Change

As is evident from Table 19, most villages have considerably increased their population base since 1941. All but four villages showed an increase in population with 29 more than doubling their population. The overall growth rate of the villages at 110 per cent is below that of the study area as a whole (165 per cent). Most of the slow growth villages, however, are outside the basic urban corridor townships, i.e. north and west of the Waterloo-Orangeville zone line. This north-west area contains 30 of the villages including all four villages with declining populations and 12 of the 14 villages which grew less than 25 per cent from 1941 to 1966. Of the fast growth villages, i.e. those that increased 100 per cent or more since 1941, 23 of the 29 are inside the basic urban corridor. Not unexpectedly, these villages largely coincide in location with the major urban shadow and urban fringe areas noted for the land space matrix. Moreover, the six fast growth villages outside the basic urban corridor are all located within 10 miles of the northern limits of the City of Waterloo. Interviews conducted for village shopping and employment flows show that these six villages are clearly linked to the Kitchener-Waterloo urban complex.

How are population increase and functional change generally related? While the population increase in total for all villages was 110 per cent, total functional units increased only 11 per cent. Thus, each functional unit "served" 36 people in 1966 compared with only 19 in 1941. When, more realistically, only central place functional units are used, the average threshold level increases because central place functional units in total declined eight per cent from 1941 to 1966. Consequently, each central place functional unit "served" 50 people by 1966 compared with 22 in 1941.

Population, thus, has increased much more rapidly than commercial functions. In part, this more rapid increase of population is related to technological marketing changes which led to larger threshold levels, resulting in larger establishments. Equally or more important, however, is the rapidly increasing residential function of villages in the major urban shadow and urban fringe areas. Population per central place function has thus clearly increased; a scatter diagram check showed, however, that village population and village functional units are still strongly associated.

Rather similar results were obtained for the Hamilton to London area 1941-1961 (Russwurm, 1964). There village population per central place increased from 19 to 43—a similar magnitude of increase though threshold levels in both years were slightly

lower. Also, in the Hamilton to London area 1941-1961, central place functions increased slightly in number as compared with the slight decline in the Toronto to Stratford area. Whether the five-year period from 1961 to 1966 is related to these minor differences is not known at present but is under investigation. However, overall village population growth in the Hamilton to London area at 143 per cent was higher than for the Toronto to Stratford area.

Central Place Functional Classes

The number of villages in which a central place functional class occurs and the probability of such occurrence is given for 1941 and 1966 in Table 20. Functional classes having the probability of occurring in at least one-half the villages in 1941 were general stores (0.96), blacksmith or welding shops (0.77), grist mills (0.64) and service station-garages (0.56). All these functional classes are 4 digit S.I.C. classes. By 1966, only three functional classes occurred in over half the villages, namely general stores (0.87), service station-garages (0.77) and building materials-hardware-farm equipment (0.59) — a 2-digit S.I.C. class.

Generally, the agricultural service functions still tend to characterize the villages in any discussion of the most frequently occurring central place functional classes.

Central place functional classes can also be described as more frequently and less frequently occurring since 1941. Of the 22 functional classes, eight occurred more frequently in 1966 while 15 occurred less frequently than in 1941 (see Table 20). It is these eight more frequently occurring functional classes which indicate that expanding urbanization is affecting the functional structure of the villages. More and more villages, instead of being relatively isolated urban sub-systems with their own small urban field, are becoming part of the total urban system while still providing certain services for their urban field.

Though part of the increase in these eight functional classes is related to technological or consumer preference changes, most of the increase can be attributed to threshold levels for the more specialized higher order goods which are increasingly made possible through urban population growth and mobility. Probability increases of 0.10 or more are noted for wholesaling outlets (0.16), building materials-hardware-farm equipment outlets (0.24), other general merchandise stores (0.13), service station-garages (0.21), eating-drinking places (0.28) and other miscellaneous retail stores (0.18).

The other side of the coin is the central place functional classes which decreased in frequency of occurrence. Of the 14 such classes, only six had probability declines of more than 0.10. Decline for most of these functional classes is a result of technological change and economies of scale. For example, blacksmith and welding shops (0.62), fuel and ice dealers (0.29), grist mills (0.36) and meat markets (0.29).

TABLE 20

VILLAGE FUNCTIONAL CLASSES, 1941 AND 1966

S.I.C. Code	Functional Class	1941 Number of Villages Occurring	1966 Number of Villages Occurring	1941-1966 Probability of Occurring		1941-1966 Change in Probability
CENTRAL PLACE						
0713	Grist Mills	48	21	0.64	0.28	–0.36
50	Wholesaling	9	21	0.12	0.28	+0.16
52	Building Materials, Hardware and Farm Equipment	26	44	0.35	0.59	+0.24
5393	General Stores	72	65	0.96	0.87	–0.09
53	General Merchandise	3	13	0.04	0.17	+0.13
5411	Grocery Stores	34	29	0.41	0.39	–0.02
5422	Meat Markets	26	12	0.35	0.16	–0.19
54	Other Food	22	17	0.29	0.23	–0.06
5541	Service Station-Garages	42	56	0.56	0.77	+0.21
55 & 75	Other Automotive Services	24	23	0.32	0.31	–0.01
56	Apparel and Accessories	15	13	0.20	0.17	–0.03
57	Furniture and Home Furnishings	19	21	0.25	0.28	+0.03
58	Eating and Drinking Places	5	26	0.07	0.35	+0.28
5962	Hay, Grain and Feed Stores	26	22	0.35	0.29	–0.06
598	Fuel and Ice Dealers	30	8	0.40	0.11	–0.29
59	Other Miscellaneous Retail Stores	16	29	0.21	0.39	+0.18
603	Banks	28	27	0.37	0.36	–0.01
7011	Hotels-Motels	30	17	0.40	0.23	–0.17
72	Personal Services	17	8	0.23	0.11	–0.12
7699	Blacksmith and Welding Shops	56	11	0.77	0.15	–0.62
76	Miscellaneous Repair Services	18	6	0.24	0.08	–0.16
78 & 79	Amusement and Recreation Services	6	7	0.08	0.09	+0.01
NON-CENTRAL PLACE		41	55	0.55	0.73	+0.18
17	Special Trade Contractors	17	41	0.23	0.55	+0.32
42 & 48	Transportation and Communications	7	18	0.09	0.24	+0.15
Manufacturing		36	48	0.48	0.64	+0.16
20	Food	18	22	0.24	0.29	+0.05
22	Textile Mill	6	1	0.08	0.01	–0.07
23	Apparel	0	7	0.00	0.09	+0.09
24	Lumber and Wood	14	16	0.19	0.21	+0.02
25	Furniture and Fixtures	1	8	0.01	0.11	+0.10
27	Printing and Publishing	7	13	0.09	0.17	+0.08
28	Chemical	0	3	0.00	0.04	+0.04
30	Rubber and Plastic	2	6	0.03	0.08	+0.05
31	Leather	4	2	0.05	0.03	–0.02
32	Stone, Clay and Glass	6	7	0.08	0.09	+0.01
33	Primary Metals	2	4	0.03	0.05	+0.02
34	Fabricated Metals	1	6	0.01	0.08	+0.07
35	Machinery - except Electrical	3	19	0.04	0.25	+0.21
36	Electrical Machinery	3	2	0.04	0.03	–0.01
37	Transportation Equipment	1	3	0.01	0.04	+0.03
38	Precision Instruments	1	1	0.01	0.01	0.00

Non-Central Place Functional Classes

It has already been emphasized that non-central place functions are becoming more important in the economic support of the villages. Moreover, it is these functions and population growth which tie in the villages with the expansion of urbanization across the study area. By 1966, the probability of a village having a non-central place functional class was 0.70 compared with 0.55 in 1961.

Non-central place functional classes for villages are given in Table 20. The three major groups of manufacturing, special trade contractors (carpenters, painters, plumbers and so on), and transportation and communications, all had increased probabilities of occurrence. The most noticeable probability increase occurred for special trade contractors from 0.23 to 0.55; in actual functional units, the increase was from 25 to 129. Similar results were obtained in my Hamilton to London study for 1941-1961 (Russwurm, 1964).

Of the 21 major manufacturing groups used by the United States S.I.C., 16 occurred in the villages by 1966 (see Table 21). In total, the number of manufacturing functional units approximately doubled from 87 to 170. While the food products manufacturing group remains the most important in 1966, it now accounts for only 25 per cent of the manufacturing functional units compared with 38 per cent in 1941. This group includes creameries and butter and cheese factories which were especially common in 1941, and of course, depend upon the rich agricultural base of much of the study area. The second most important manufacturing group in 1941—lumber and wood products—was replaced by the machinery, except electrical group in 1961. Again, these results are similar to those obtained in the Hamilton-London corridor study (Russwurm, 1964).

The Village Functional Structure

In an attempt to assess the functional mix of the villages, resort was again made to the factor analysis technique. Do identifiable associations of functional classes occur? If so, has the structure remained similar from 1941 to 1961? These were the questions for which hypotheses or answers were sought using factor analysis.

The input variables for the factor analyses were the number of functional units in each functional class in each village. Twenty-two central place and four non-central place functional classes made up the data input matrix. Manufacturing was grouped into two functional classes: food and other manufacturing. The same operating rules used in the factor analysis of the land space matrix were followed. Thus, only factors explaining five per cent or more of the total variance and having at least four variables which load significantly are interpreted.

Village Factor Analysis 1941

For 1941, four factors explaining 48 per cent of the total variance are interpreted. Basic data on these factors are presented in Table 21, including factor scores for villages having scores of 1.0 or −1.0 or higher on each of the four factors.

TABLE 21

VILLAGE FUNCTIONS FACTOR ANALYSIS RESULTS, 1941

74.2% variance explained by 7 factors

FACTOR 1 FULLY SERVICED CENTRAL PLACE

28.4%, 14 Variables

Variable Name	Variable Loading
Special Trade Contractors	0.59
Building Materials, Hardware, Farm Equipment	0.77
General Merchandise	0.76
Grocery Stores	0.77
Meat Market	0.83
Other Food	0.76
Service Station Garage	0.67
Other Automotive Services	0.52
Apparel and Accessories	0.64
Furniture and Home Furnishings	0.86
Fuel and Ice Dealers	0.66
Other Miscellaneous Retail Stores	0.80
Banks	0.52
Personal Services	0.65

Highest Factor Scores

Village	Factor Score
Ayr	1.43
Bolton	1.19
Drayton	2.08
Elora	2.63
Erin	2.72
New Hamburg	1.13
Tavistock	5.65
Conestogo	−1.09

FACTOR 2 SPECIAL MIX OF CENTRAL PLACE FUNCTIONS

10.0%, 4 variables

Variable Name	Variable Loading
Hay, Grain & Feed Dealers	0.51
Hotels-Motels	0.60
Miscellaneous Repair Services	0.80
Food Manufacturing	0.51

Highest Factor Scores

Village	Factor Score
Baden	2.73
Conestogo	2.08
Linwood	1.36
Milverton	1.00
Moorefield	1.27
New Hamburg	3.85
Wellesley	3.97
Elora	−1.37
Erin	−1.82
Tavistock	−1.08

FACTOR 3 OTHER MANUFACTURING-WHOLESALING

9.4%, 3 variables

Variable Name	Variable Loading
Wholesale Trade	0.83
Blacksmith-Welding	0.62
Other Manufacturing	0.76

Highest Factor Scores

Village	Factor Score
Campbellville	1.34
New Dundee	2.38
Petersburg	1.40
Rockwood	2.27
St. Jacobs	6.38
Elora	−1.26

FACTOR 4 SPORADIC - UBIQUITOUS CENTRAL PLACE FUNCTIONAL MIX

9.1%, 4 variables

Variable Name	Variable Loading
Eating-Drinking Places	0.67
Fuel and Ice Dealers	0.54
Bank	0.50
Amusement-Recreation Services	0.76

Highest Factor Scores

Village	Factor Score
Elora	3.96
Malton	3.13
Milverton	3.98
Moorefield	1.24
St. Jacobs	1.28
Sebringville	1.79
Baden	−1.19
Gadshill	−1.08
New Dundee	−1.32
Tavistock	−2.66

Factor 1, explaining 28 per cent of the variance, is identified as consisting of those functional classes which occur together in a *fully serviced central place.* Thus, almost the full range of retail trade functional classes plus special trade contractors, personal services and banking services, all load positively on this factor. Villages with high positive factor scores will thus be villages serving as partial shopping centres using the Borchert and Adams classification (Borchert and Adams, 1963). They should have 26 to 45 central place functional units providing more specialized goods like appliances, furniture and clothing. They will be villages in which manufacturing is relatively unimportant; the central place functions are thus the dominant economic support of these villages. Certainly, the seven villages with the highest positive factor scores in 1941 fit this description—Tavistock, Erin, Elora, Drayton, Ayr, Bolton, New Hamburg.

The greatest part of the variance having been explained by the basket of goods and services usually occurring in a strongly central place oriented village, other factors will identify less important functional structure characteristics. For example, Factor 2, *Special Mix of Central Place Functions* explains 10 per cent of the variance by grouping four somewhat different functional classes. While seemingly diverse, they are associated with strongly oriented agricultural service centres. Food manufacturing in 1941 consisted mainly of creameries and butter-cheese factories. The association with hotels serving alcohol may reflect some German ethnic influences since all six villages having high positive factor scores are located north and west of the Kitchener-Waterloo urban area.

Other Manufacturing-Wholesaling is the name given to Factor 3 which accounts for 9.4 per cent of the total variance. Even though only three variables load significantly on this factor, it is included because it suggests that in some villages a wholesale trade function existed in 1941, that wholesale trade was associated with manufacturing other than food but also particularly with blacksmith shops. Thus, St. Jacobs which has by far the highest score on this factor, was the only village with three wholesale functional units; was one of the villages having three blacksmith shops and was also first in the study area with its six manufacturing outlets. Detailed interpretations of this and other factors are possible by checking Appendix D on village functional units and Appendix E on village factor scores.

The final factor interpreted for 1941 has been labelled *Sporadic-Ubiquitous Central Place Functional Mix.* Explaining 9.1 per cent of the total variance, this factor consists of infrequently occurring functions: eating-drinking places—really restaurants (probability 0.07); and amusement-recreation service—really billiard centres (probability 0.09); and rather frequently occurring functions, banks (probability 0.37) and fuel and ice dealers (probability 0.40). High positive factor scores single out villages having all of these functions; high negative factor scores single out villages having none of these functions or only one of the more ubiquitous functions of banking and fuel and ice dealers.

Village Factor Analysis, 1966

For 1966, only three factors are interpreted but these three factors account for 53 per cent of the total variance with 21 of the 26 variables loading significantly on one of these factors. The three factors have been named *Expanding Urbanization, Fully*

Serviced Central Place and Special Mix of Central Place Functions (Table 22). With regard to the land space matrix factor analysis, the 1966 factors tend to be more complex and more difficult to interpret. Such a result does, however, support the notion that the most complex urban nodes, the cities, are increasingly incorporating the villages into the net of the urban system. Because of this increased complexity, the factors for 1941 and 1966 are not similar and 1941 to 1966 cross sectional change is discussed separately later.

Factor 1, *Expanding Urbanization,* reflects this increased urbanization impact. Two of the four non-central place functional classes used in the analysis, special trade contractors and other manufacturing, load highly on this factor (0.76 and 0.91 respectively). All but two of the ten functional classes loading significantly on this factor have an increased probability of occurring in a village of 0.13 or more as compared to the 1941 probability of occurrence. In fact, except for the transportation-communications functional class, this factor includes all functional classes which increased their probability of occurring in a village 0.13 or more by 1966. This factor then reflects the impact of expanding urbanization across the study area in general and the effect of population growth in particular.

Villages scoring highly positive on this factor include the three larges villages—Malton, New Hamburg and Bolton. Of the villages in the study area with 1,000 or more people in 1966, only two score slightly negatively on this factor. As well, villages scoring positively on this factor tend to be high growth rate villages (compare Table 22 and Appendix E). Basically then, this factor points out the mix of functional classes that tend to occur together in the larger, relatively faster growing villages—information of use for planning purposes. One warning comment on the interpretation of this factor: the 19 other manufacturing functional units recorded for Malton in 1966 are 11 more than the largest number occurring in any other village; this relatively high number has contributed to Malton's high factor score and may have exerted undue influence in the functional unit matrix.

The second factor, *Fully Serviced Central Places,* explains 18 per cent of the total variance. It consists of a cluster of functional classes which point up those villages acting as partial shopping centres for a prosperous surrounding agricultural area and for their own inhabitants. These villages may or may not be fast growth (900 per cent or more increase 1941-1966) depending on location, but all appear to have retained dominance over their own urban field. Seven of the villages having high positive scores on this factor were included in the random selection for interviewing on shopping and employment flows; all showed high summed power indices indicating that most goods and services needed by their inhabitants and likely of the surrounding inhabitants are acquired in these villages (see Part VI). Additional support for this interpretation of Factor 2 is gained from the high negative factor scores derived for Malton and Bridgeport, both urban fringe villages with large percentage increases of population since 1941.

Accounting for 11 per cent of the total variance is the third factor, *Special Mix of Central Place Functions.* Combined in this factor are three relatively infrequently occurring functional classes—meat markets (probability 0.16), fuel and ice dealers (probability 0.11), and amusement and recreation services (probability 0.09) and one

TABLE 22

VILLAGE FUNCTIONS FACTOR ANALYSIS RESULTS, 1966

77.3% of variance explained by 7 factors

FACTOR 1 EXPANDING URBANIZATION

24.0%, 10 variables

Variable Name	Variable Loading
Special Trade Contractors	0.76
Wholesale Trade	0.88
Building Materials, Hardware, Farm Equipment	0.55
General Merchandise	0.75
Service Station Garages	0.32
Other Automotive Services	0.73
Eating and Drinking Places	0.50
Other Miscellaneous Retail Stores	0.65
Banks	0.61
Other Manufacturing	0.91

Highest Factor Scores

Village	Factor Score
Ayr	1.04
Bolton	2.90
Malton	6.63
New Hamburg	1.83
St. Jacobs	1.59
Moorefield	–1.02

FACTOR 2 FULLY SERVICED CENTRAL PLACE

17.7%, 8 variables

Variable Name	Variable Loading
Building Materials, Hardware, Farm Equipment	0.55
Grocery Store	0.75
Other Food	0.52
Apparel and Accessories	0.88
Furniture and Home Furnishings	0.54
Other Miscellaneous Retail Stores	0.53
Personal Services	0.86
Food Manufacturing	0.64

Highest Factor Scores

Village	Factor Score
Bolton	3.16
Drayton	2.94
Elora	1.16
Erin	1.48
New Hamburg	3.54
Tavistock	1.57
Waterdown	3.43
Wellesley	1.82
Bridgeport	–1.56
Malton	–2.34

FACTOR 3 SPECIAL MIX OF CENTRAL PLACE FUNCTIONS

10.9%, 4 variables

Variable Name	Variable Loading
Meat Market	0.83
Hay, Grain and Feed Store	0.69
Fuel and Ice Dealers	0.72
Amusement and Recreation Services	0.57

Highest Factor Scores

Village	Factor Score
Ayr	1.01
Bridgeport	2.27
Elora	1.60
Erin	3.55
Milverton	3.30
Moorefield	3.15
Rockwood	2.02
Tavistock	2.46
Drayton	–1.20
New Hamburg	–1.67

more commonly occurring functional class—hay, grain, and feed stores (probability 0.29). Villages scoring highly positive on this factor will tend to have all four of these functional classes occurring. Again, most of the highest factor scores are associated with larger villages. This development points out that the use of nominal data such as frequency counts of functional classes by villages, leads to the results that those villages having the larger number of functional units tend to contribute most to the variance and hence to the factor scores.

Cross-Sectional Change in the Factor Structure 1941 to 1966

In both 1941 and 1966, seven factors accounted for about three-quarters of the total variance expressed in the way different functional units occurred among the villages. While the factors interpreted showed some similarity between 1941 and 1966, none were exactly similar.

In 1941, Factor 1, *Fully Serviced Central Places,* was the dominant factor—28 per cent compared to 10 per cent variance for the second factor—*Special Mix of Central Place Functions.* For the village nodes, this dominance suggests that villages in 1941 basically provided a bundle of central place goods for their trade area. The analysis of the land space matrix or the surface in which the village nodes are set indicates that in 1941 the study area was still in a pre-urban expansion stage. The dominance of Factor 1 in the functional structure of the villages in 1941 indicates the same thing.

By 1966, the *Fully Serviced Central Place* factor broke into two factors accounting together for 42 per cent of the total variance. The name—*Fully Serviced Central Places*—was retained for one factor; the other factor was named *Expanding Urbanization.* Together these two factors in 1966 contained 13 of the 14 variables which made up Factor 1 in 1941. However, Factor 1 in 1966 also absorbed the key functional classes wholesaling and other manufacturing used to name Factor 3 in 1941. These two functional classes are usually important in higher levels of the urban hierarchy designated as complete shopping or wholesale-retail centres (Borchert and Adams, 1963). Hence, the basic duality of the role of villages as part of an expanding urban system is exemplified in the reorganization of Factors 1 and 3 for 1941 into Factors 1 and 2. From an economic functional standpoint, villages today still provide the basic services for their urban field but at the same time are integrated more and more into the expanding urban system of their particular region and interact with that larger urban system.

Another reorganization took place for the remaining two factors interpreted for 1941. Both Factor 2 and Factor 4 for 1941 consisted of special mixes of central place functions plus the associated non-central place functional class of food manufacturing. For 1966, only one factor was interpreted with a special mix of central place functional classes. From Factor 2, 1941, food manufacturing disappeared into the *Fully Serviced Central Place* factor by 1966; miscellaneous repair services and hotels-motels did not load significantly on any of the three 1966 factors; and hay, grain and feed dealers loaded on Factor 3—*Special Mix of Central Place Functions* for 1966.

Added to the hay, grain and feed dealers were fuel-ice dealers and amusement-recreation services from Factor 4, *Sporadic-Ubiquitous Central Place*

Functional Mix for 1941. The fourth functional class, meat markets in the special mix factor for 1966 came from Factor 1, *Fully Serviced Central Places, 1941.* Clearly, then, the special mix factor for 1966 is just that: a diverse group of functional classes which tend to occur together in this particular group of villages—undoubtedly some sort of special mix will occur among the villages of any region and this mix will vary from region to region reflecting local factors and random decisions of location.

Functional Grouping And Change

The second objective of this functional analysis of villages is to provide an objective grouping of villages based on both the raw data (functional units), and the structural components (factor scores) revealed in the factor analyses. Other researchers have provided taxonomies of cities and their position in multidimensional urban space. Most pertinent are the studies by King and by Ray, et al on Canadian cities and by Bunting and Baker on Ontario-Quebec cities (King, 1966, Ray, et al, 1968, Bunting and Baker, 1968). Villages, too, vary as the analysis of the factor structure above reveals. Such a classification will summarize the similarities among the villages as part of the Toronto-Stratford corridor urban system. While the resultant groupings are sometimes difficult to interpret, they may indicate some total functional characteristics which should be considered for future development of these villages.

The grouping routine used is Program H Group (Veldman, 1967). This routine compares a series of score profiles (here factor scores or functional units of the villages) and progressively associates them into groupings in such a way as to minimize the overall variance within the groups, while maximizing it between groups. The range of groups can be one group per observation (here village) to all observations in one group. The usual criteria for deciding on number of groups to be utilized is to cut-off where total within-group variance increases suddenly. Thus, at the beginning of the grouping process for the villages, 75 groups would result and the "error within" each group is, therefore, zero. As the number of groups increase and more villages are included the "error within" the groups will usually increase.

One input for the village grouping was the factor scores for the seven factors identified for both 1941 and 1966. The H-Group Program was also run using the raw data of the numbers of different functional units in each village. Since the results were not exactly the same, except that both are difficult to interpret without recourse to the detailed input data, both are briefly discussed. The village groups for 1966 are presented first; then the 1941 groups are presented and briefly compared with the 1966 groups.

Village Groups, 1966

Given 72 villages (three small villages were inadvertently omitted but are almost certainly in Group 1), it was deemed sensible to opt for less than 10 groups to analyze. Increase in error was thus checked in the reductions from 10 groups to successively fewer groups. Two possible numbers of groups based on error increase were feasible. Either seven groups or four groups could be accepted for 1966. Since the four groups solution had the same 56 villages in Group 1, it was selected and comments are included on the reduction from seven to four groups. For 1941 either six groups or four groups could be accepted. For easier comparability four groups were also accepted.

TABLE 23

FACTOR SCORE VILLAGE GROUPING, 1966

Group 1 (59 villages)

Aberfoyle
Alma
Ayr
Ballinafad
Belwood
Blair
Bloomingdale
Branchton
Breslau
Caledon
Campbellville
Cheltenham
Conestogo
Doon
Eden Mills
Floradale
Gadshill
Glen Allan
Glen Williams
Hawkesville
Heidelberg
Hillsburgh
Huttonsville
Inglewood
Limehouse
Linwood
Marsville
Maryhill
Meadowvale
Millbank
Mono Mills
Mono Road
Morriston
New Dundee
Newton
Norval
Orton
Ospringe
Palermo
Palgrave
Petersburg
Puslinch
Rostock
Rothsay
St. Agatha
St. Clements
St. Jacobs
St. Pauls
Salem
Sand Hill
Sebringville
Shakespeare
Snelgrove
Terra Cotta
Victoria
Wallenstein
Wellesley
West Montrose
Winterbourne

Group 2 (9 villages)

Alton
Baden
Bolton
Caledon East
Carlisle
Drayton
New Hamburg
Tavistock
Waterdown

Group 3 (6 villages)

Bridgeport
Elora
Erin
Milverton
Moorefield
Rockwood

Group 4 (1 village)

Malton

TABLE 24

FUNCTIONAL UNIT VILLAGE GROUPING, 1966

Group 1 (37 villages)

Aberfoyle
Ballinafad
Belwood
Blair
Bloomingdale
Branchton
Carlisle
Cheltenham
Conestogo
Doon
Eden Mills
Gadshill
Glen Allan
Glen Williams
Heidelberg
Huttonsville
Limehouse
Marsville
Maryhill
Meadowvale
Millbank
Mono Road
New Dundee
Newton
Orton
Ospringe
Puslinch
Rostock
Rothsay
St. Pauls
Salem
Sandhill
Snelgrove
Terra Cotta
Victoria
West Montrose
Winterbourne

Group 2 (16 villages)

Alma
Breslau
Caledon
Caledon East
Campbellville
Inglewood
Mono Mills
Moorefield
Morriston
Norval
Palermo
Palgrave
Petersburg
St. Agatha
Sebringville
Shakespeare

Group 3 (16 villages)

Alton
Ayr
Baden
Bridgeport
Drayton
Elora
Erin
Floradale
Hawkesville
Hillsburgh
Linwood
Milverton
Rockwood
St. Clements
Wallenstein
Wellesley

Group 4 (6 villages)

Bolton
Malton
New Hamburg
St. Jacobs
Tavistock
Waterdown

For both the factor score and the functional unit inputs in 1966, sizeable error increase occurred in going from four to three groups, hence four groups are acceptable (Table 23 and Table 24). For the functional unit grouping in combining seven to four groups, Group 1 and Group 2 remained the same; for the factor score grouping the large Group 1 remained the same. Both groupings are difficult to interpret without recourse to the detailed input data, except to generally suggest that factor score Group 1 and functional unit Groups 1 and 2 generally indicate minimal villages and factor score Groups 2, 3, and 4 and functional unit Groups 3 and 4 indicate the more fully developed villages. However, detailed checks on functional units, population and factor scores are required to properly clarify the "why" of the groupings. Hence, more detailed work is needed to sort out whether these groups are useful for regional planning purposes or whether they are mainly mathematical artefacts. Multiple regression using factor scores for only the three factors interpreted as independent variables and population, total functional units, central place functional units and population growth 1941 to 1966, might reveal possible insights into the full explanation of the village groups. A check using central place functional units only showed that villages could be grouped into three non-overlapping groups of 3-8, 10-17, and 20-43 central place functional units containing respectively 47, 15 and 13 villages.

Village Groups, 1941

As Tables 25 and 26 indicate, four groups were again accepted. And in reducing from six groups to four groups for both the factor score and functional unit inputs, the large Group 1 remained intact. Again, basically the larger villages with the greater number of functional units or central place units or higher factor scores on the four factors interpreted earlier, make up Groups 2, 3, and 4 and Group 1 contains mostly the minimal villages. Apparent peculiarities exist. For example, why should Ayr, Belwood and Bolton occur together in the factor score grouping? A thorough check of all seven factors disclosed that these three villages were the only villages having a communication functional unit in 1941. Similarly, Group 3, consisting of two small villages, Orton and Shakespeare, one medium size village, Hillsburgh and one large village, Waterdown, were the only four villages in 1941 possessing a Transportation Functional Unit. For future use of the H Group program on factor scores, the recommendation is to use only the scores from the major factors (see also Bunting and Baker, 1968).

Nor did a check of central place functional units for 1941 show a clear grouping without some overlap. Three groups could be reasonably accepted, however, based on 3-6, 7-12 and 15-57 central place functional units; respectively, these groups would consist of 38, 13 and 24 villages. In the Hamilton to London study (Russwurm, 1964), three non-overlapping groups of villages, which showed considerable stability from 1941 to 1961, were identified based on four-digit S.I.C. central place functions.

Among the Toronto to Stratford village grouping considerable shifting occurred. For instance, for the functional unit groups between 1941 and 1966, 31 of the 37 villages in Group 1 in 1966 were in Group 1 in 1941, while the group size declined from 49 to 37 villages. Only three villages remained in Group 2 from 1941 to 1966, as the group size increased from 13 to 16. Further comparisons of the tables will show that considerable shifting occurred, supporting the notion that expanding urbanization has affected the overall functional structure in various ways.

TABLE 25

FACTOR SCORE VILLAGE GROUPING, 1941

Group 1 (59 villages)

Aberfoyle
Alma
Alton
Baden
Ballinafad
Blair
Bloomingdale
Branchton
Breslau
Bridgeport
Caledon
Caledon East
Campbellville
Carlisle
Cheltenham
Conestogo
Doon
Eden Mills
Floradale
Gadshill
Glen Allan
Glen Williams
Hawkesville
Heidelberg
Huttonsville
Inglewood
Limehouse
Linwood
Marsville
Maryhill
Meadowvale
Millbank
Mono Mills
Mono Road
Moorefield
Morriston
New Dundee
Newton
Norval
Ospringe
Palermo
Palgrave
Petersburg
Puslinch
Rockwood
Rostock
Rothsay
St. Agatha
St. Clements
St. Pauls
Salem
Sandhill
Snelgrove
Terra Cotta
Victoria
Wallenstein
Wellesley
West Montrose
Winterbourne

Group 2 (9 villages)

Drayton
Elora
Erin
Malton
Milverton
New Hamburg
St. Jacobs
Sebringville
Tavistock

Group 3 (4 villages)

Hillsburgh
Orton
Shakespeare
Waterdown

Group 4 (3 villages)

Ayr
Belwood
Bolton

TABLE 26

FUNCTIONAL UNIT VILLAGE GROUPING, 1941

Group 1 (49 villages)

Aberfoyle
Alma
Alton
Belwood
Blair
Bloomingdale
Branchton
Breslau
Bridgeport
Caledon
Carlisle
Cheltenham
Conestogo
Eden Mills
Elora
Erin
Floradale
Glen Williams
Hawkesville
Heidelberg
Huttonsville
Inglewood
Limehouse
Marsville
Maryhill
Meadowvale
Millbank
Milverton
Mono Mills
Mono Road
Moorefield
Morriston
Newton
Norval
Orton
Ospringe
Palgrave
Puslinch
Rostock
Rothsay
St. Agatha
Sandhill
Snelgrove
Terra Cotta
Victoria
Wallenstein
Waterdown
West Montrose
Winterbourne

Group 2 (13 villages)

Ayr
Ballinafad
Bolton
Campbellville
Doon
Drayton
Gadshill
Glen Allan
Palermo
St. Clements
St. Pauls
Salem
Sebringville

Group 3 (7 villages)

Baden
Caledon East
Hillsburgh
Linwood
New Dundee
New Hamburg
Tavistock

Group 4 (6 villages)

Malton
Petersburg
Rockwood
St. Jacobs
Shakespeare
Wellesley

The next step in the suggested urban system approach, as outlined earlier, would be to analyze the locational structure of the towns and cities. Because of time constraints, and because the data available for this type of analysis would largely come from published census tables, this analysis is not undertaken. Instead, the two parts which follow deal with the interactional sub-system of the total urban system—first, shopping and employment flows, 1967, for a random sample of peripheral villages are analysed; second, for the major nodes, the cities and towns, message flows, involving long distance telephone calls, mail flows and newspaper circulation are analysed using a simple gravity model approach. Ontario Department of Highways origin-destination flows of traffic available from their area studies are not analysed because of time constraints and the amount of effort needed to make their different area studies comparable. However, such a study needs to be undertaken because the data available for the land space matrix can be compiled by D.H.O. traffic zones. Such data are currently being used by Russell Muncaster, Department of Geography, Waterloo Lutheran University in his Ph.D. Thesis for Clark University on the topic of Central Place hierarchies.

PART VI

PERIPHERAL VILLAGES AND FLOWS OF PEOPLE

Hypotheses And Data

Basic Hypotheses

Based on Central Place Theory, a hypothesis was developed which stated that by outlining the trade area of villages situated peripherally to nearby cities the influence sheds of cities could be determined (Berry, Pred, 1961). Such a hypothesis is based on the central place assumptions that (1) shoppers go to the nearest place to obtain a particular good, if that place can provide it at a price and a quality which satisfies the perceived preference of the shopper and (2) that a central place hierarchy exists such that people living in lower order central places will usually obtain higher order goods from the nearest higher order place providing that good. A concomitant assumption, supported by empirical evidence, is that people living in the rural areas surrounding central places usually use the nearest central place for whatever goods that place offers. Thus, by determining the shopping flows of villages situated peripherally to the cities in the study area, the urban fields of the cities can be defined. Simultaneously, data can be analysed for the flows of people for different goods and services and for place of work.

Using similar reasoning, employment sheds of cities presumably can be defined by noting the pattern of flows to work from villages situated peripherally to nearby cities. However, no sophisticated theoretical base, such as central place theory for shopping, is available for flows to work. The limited evidence available does support notions that flows to work can generally be fitted by various modifications of gravity models (Lonsdale, 1966, Allen, 1967, Reed, 1969).

As far as I am aware, no real research work has been specifically done on the interrelations between flows to work and flows for shopping from villages, except for Hill's study (Hill, 1969). Using the interview information for 1967 from the peripheral villages in the Stratford-Toronto area, statistical methods are used to throw some light on such interrelationships. The second basic hypothesis postulated here then, is that the place of work tends to overcome the basic central place hypothesis for shopping, i.e., that place of work tends to attract shopping for goods and services which might otherwise not occur.

The Data Source

The basic source of data used to test the hypotheses stated above was field interviews in villages designated as peripheral villages. Data on work place and ten goods or services were obtained using the attached questionnaire. The ten goods or services were deliberately selected to include lower order convenience needs required frequently, e.g., groceries, car services; lower order convenience needs required less frequently, e.g., hardware, banking; higher order shopping needs, e.g., appliances, furniture, clothing, shoes, car purchase; and three types of personal services, lawyer, doctor and dentist, of

which general doctor services are a lower order than the services provided by lawyers and dentists (Hill, 1969).

Using the 75 places defined as villages, i.e., places having three or more functional units in both 1941 and 1966 as the basic observation units, a random selection of peripheral villages (defined below) for interviewing was made. A 50 per cent sample of peripheral villages was desired.

Because of time and expense limitations, only a 47 per cent random sample was achieved with interviews conducted in 21 of 45 peripheral villages. The random sampling was carried out using only peripheral villages. This sample size accounts for 27 per cent of all villages; however, 30 villages had no opportunity of being selected.

Peripheral villages are defined using three criteria. (1) Peripheral villages are villages outside a 10-mile radius of the centre of a city having a population of 50,000 or more or outside a 10-mile radius of the centre of a census metropolitan area. In the study area as defined, the Kitchener Metropolitan area is completely contained, while the Hamilton Metropolitan area, which includes Hamilton, Burlington, Dundas and Stoney Creek, only fronts the study area directly through Burlington and the Toronto Metro area only fronts on its west side. (2) Peripheral villages are villages outside a 5-mile radius of the centre of cities having populations between 10,000 and 50,000. (3) Peripheral villages are villages within the urban field of two or more cities with cities defined as in criteria (1) and (2).

In this study a minimum population in 1966 of 10,000 and incorporation is used to define a city and a population range in 1966 of 2,500 to 10,000 and incorporation is used to define a town. All villages, thus, have populations under 2,500, except for Malton, which, though unincorporated, had about 4,300 people in 1966. The figure of 2,500 has some support in urban work in that it is the minimum figure used to define an urban place by the U.S. Census. Similarly, the figures of 10,000 and 50,000 have support from census usage; both the Canadian and the U.S. Census use 50,000 as the minimum population for a central city of a metropolitan area; and, in the Census of Canada, the population of 10,000 is a breaking point population, since very limited data are made available on urban places of less than 10,000.

Figure 22 shows the peripheral villages resulting from the combination of the above criteria. The villages interviewed are listed on Table 27, entitled *Peripheral Village Interviews.*

Within the randomly selected peripheral villages, a one in three systematic sample of households was used for interviewing. The interview schedule is included as Table 28, entitled *Interview Schedule for Peripheral Village Flows.* Questions were asked on place of work, places of shopping, and family make up (see Table 28); also the place of work of the nearest two neighbours was requested. Where refusals occurred, or people were not at home, the next house was interviewed. Thus, some bias may exist because of no call back and because of interviewing households more apt to have someone at home.

TABLE 27

PERIPHERAL VILLAGE INTERVIEWS, 1967

	Village Code	No. of Interviews
Alma	102	14
Ballinafad	106	9
Bolton	110	100
Caledon	114	14
Carlisle	117	36
Cheltenham	118	11
Drayton	121	44
Erin	124	67
Gadshill	126	6
Hawkesville	129	11
Meadowvale	139	15
Mono Road	143	6
Moorefield	144	18
New Hamburg	147	140
Puslinch	155	4
Rostock	157	7
Rothsay	158	6
Salem	163	20
Tavistock	168	66
Wallenstein	171	9
Wellesley	173	44
Total Interviews		647

TABLE 28

INTERVIEW SCHEDULE FOR PERIPHERAL VILLAGE FLOWS

CONFIDENTIAL

Place ____________________

University of Waterloo, Planning and Resources Institute
Stratford to Toronto Urbanization Study
Professor Lorne H. Russwurm

A EMPLOYMENT

1. Number of people living in household ____________

2. Employed People

(a)	Males	Place	Firm	(b)	Females	Place	Firm
	Head				Wife or Widow		
	Other				Other		

B SHOPPING

1. Place by Frequency	1	2	3
(a) Groceries			
(b) Hardware			
(c) Banking			
(d) Appliances-furniture			
(e) Clothing-shoes			
(f) Services of car			

2. (a) Place present car purchased
   (b) Lawyer
   (c) Doctor
   (d) Dentist

3. List places, if any, where you shop more frequently than you did 5 years ago.

None ____________ 1____________ 2____________ 3____________

C EMPLOYMENT OF NEIGHBOURS

1. Number of people living in household ____________

2. Employed People

(a)	Males	Place	Firm	(b)	Females	Place	Firm
	Head				Wife or Widow		
	Other				Other		

1. Number of people living in household ____________

2. Employed People

(a)	Males	Place	Firm	(b)	Females	Place	Firm
	Head				Wife or Widow		
	Other				Other		

The problems discovered in using the interview schedule are enumerated as follows:

(1) length of residence should be asked
(2) age of head of household should be asked
(3) third choice for goods given infrequently
(4) appliances, furniture purchases are sufficiently infrequent that many householders cannot answer
(5) appliances and furniture, as well as clothing and shoes, should probably be separated (Hill, 1969)
(6) car purchase involves a number of sporadic places, since people moving into an area bring along their car
(7) mail order shopping should specifically be asked about or completely omitted.

Aside from these minor difficulties, the interview schedule provided the information sought.

The interview data were keypunched and processed on the IBM 360-75 computer system at the University of Waterloo. In addition, all villages, towns and cities were coded and road distance measurements, using The Department of Highways County Maps, were taken to the nearest mile. A distance of one mile was assigned for shopping or working in the local village. And distance to cities was measured to a mid point between the outer limits of the built up area and the city centre.

Types of work were categorized into nine categories using the Canadian Standard Industrial Classification. These work type data were nominal scale and proved to be almost useless in the quantitative analyses. Possibly ordering of the work type data into a ranked, i.e., ordinal measurement scale would make such data useful (Wheeler, 1969).

In the analysis which follows, flows for shopping goods and services from peripheral villages are analysed using the power index measurement developed by Hill (Hill, 1969). Then, flows to work are analysed separately utilizing simple cartographic and statistical measurements. Maps of flows for shopping and flows to work give some indication of the shopping and employment sheds between the cities and towns. To complete the analysis, the factor analytic technique is applied to all individual interviews using 15 variables and then separately to New Hamburg to see what underlying structure exists. Finally, a multiple regression model is attempted, with limited success, with distance to work for the male head as the main independent variable and distances travelled for 10 goods and services as the dependent variables. Distance is used throughout to identify the towns and cities to which flows merge.

Analysis of Flows for Shopping Goods and Services and Employment

Flows for Shopping Goods and Services

A moderate number of studies in a North American setting exist dealing with consumer travel for goods and services (for example, Rushton, 1966, Murdie, 1965, Thomas, et al, 1962, Ray, 1968, Berry, et al, 1962, Berry, 1967A). Usually these studies utilize a sample of the dispersed rural (farm and non-farm) population and its movement for goods and services to the surrounding spatial hierarchy of villages, towns and cities.

In this research, inhabitants of villages are sampled with the underlying assumption that the dispersed population living in the area surrounding the village will behave similarly to the agglomerated population in the village node. This assumption is verified for one village in the study area by Hill's Study of Elora (Hill, 1969) and also fits into the basic postulate of central place theory. Flows for shopping goods and services should mainly be within the village for those goods and services provided by the village and up the urban hierarchy for higher order goods minimally available (e.g., clothing in a general store) or not available.

A simple flow map of shopping goods and services is presented as Figure 22. Only those destination places having a summed power index of 10.0 or more of the outflows from a village are shown in order to keep the map readily legible. The cartographic evidence is clear. Outflows are, in all cases, up the urban hierarchy to a large place—larger meaning more functional units. Very consistently, too, the dominant outflows are to the nearest larger place. Central place theory thus seems fully operative for overall shopping flows.

A word about the derivation of the index used to measure total shopping flows—the summed power index. Results for all villages are given in the Table. As was noted earlier, questions were asked about choices for the places where 10 different shopping goods and services are procured. For each good a power index is derived; the sum of the 10 individual indices divided by 100 represents the summed power index. The index, its application and the computer program used for the calculations are the work of Fred Hill and were first applied in his study of Elora (Hill, 1969).

To derive the individual power index, each interview response is given 6 points: on a 3-2-1 basis if three choices are noted; on a 4-2 basis if 2 choices are noted; and on a 6-0 basis if only one choice is noted. For the professional services of lawyer, doctor, and dentist and for car purchase only first choice was recorded. These services, therefore, tend to favourably weight an individual city or town, if the people in a given village tend to get these services primarily from that city or town. The individual indices added up to obtain the summed power index are left unweighted. Hill, in developing a place index based on the individual interview, applied weighting factors for different goods as suggested in a Canadian Government Table (Hill, 1969).

Power indices for individual goods and services are presented for the 21 villages in which interviews were conducted during the summer of 1967. The sum of each of these individual indices totals to 10. Villages have been ranked according to their summed power indices. Such a summed index, since it is a relative measure, could be used for grouping places into meaningful classes. Thus, the first six places, New Hamburg to Drayton, all have the largest index for shopping done within the village with a distinct gap between the 44.3 of Drayton and the next place, Moorefield, which has an index of 27.2. These six places are partial shopping centres. Grouping could be done on the actual index or also on the ratio of the summed power index for the village to the largest index for a destination place.

FIGURE 22

SHOPPING FLOWS OF PERIPHERAL VILLAGES

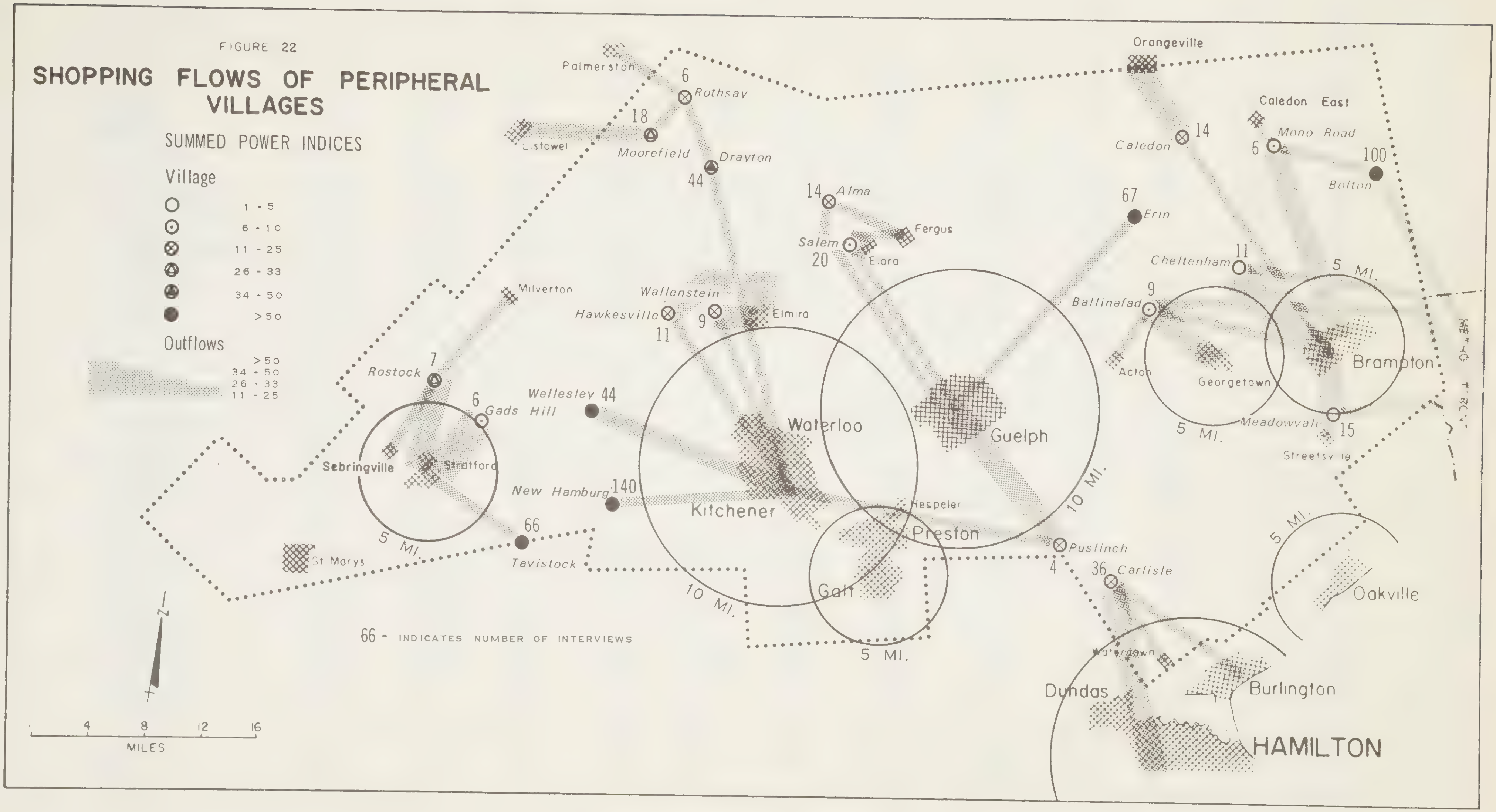


TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
New Hamburg												
New Hamburg	71.9	61.9	8.2	8.7	9.5	9.2	5.6	4.4	7.0	6.7	5.3	7.4
Kitchener	20.8	26.9	1.6	0.7	0.4	0.5	3.8	5.1	1.5	1.9	3.1	2.4
Stratford	1.6	3.1	0.1	0.2		0.1	0.2	0.2	0.4	0.1	0.3	0.1
Baden	1.4	2.9				0.1	0.2		0.2		0.9	
Waterloo	1.1	4.0		0.1			0.2	0.1	0.1	0.1	0.3	0.1
Other	3.1	1.2	0.1	0.3	0.1	0.1		0.2	0.8	1.2	0.1	
Bolton												
Bolton	63.2	26.8	9.0	6.9	9.2	8.3	4.7	3.7	2.6	6.8	8.4	3.7
Toronto	24.3	48.3	1.0	1.2	0.6	1.1	5.2	6.2	3.6	1.3	0.7	3.5
Brampton	5.3	5.0	0.1	0.7				0.1	1.5	0.5	0.1	2.5
Woodbridge	1.9	3.1		0.4		0.1	0.1		0.4	0.4	0.3	0.2
Schomberg	1.1			0.4					0.7			
Other	4.0	16.8		0.4	0.2	0.5			1.2	1.0	0.5	0.1
Tavistock												
Tavistock	57.0	67.3	7.6	7.3	9.4	8.1	7.8	4.2	3.1	9.6		
Stratford	21.6	14.8	1.7	1.8	0.4	1.2	0.9	3.3	2.9	0.3	4.8	4.3
New Hamburg	5.5	1.8	0.2	0.4		0.2	0.2		1.8		1.8	0.8
Kitchener	5.5	6.1	0.1	0.2	0.1	0.2	0.1	1.4	0.4	0.2	1.0	1.6
Woodstock	4.9	2.5	0.2			0.1	0.3	0.3	0.6		1.2	2.2
Other	5.4	7.5	0.2	0.3	0.1	0.2	0.7	0.8	1.2		1.2	1.1
Erin												
Erin	54.2	56.1	8.4	7.3	9.8	8.9	4.5	2.9	4.2	8.3		
Guelph	12.9	3.8	1.2	0.2			1.8	4.3	0.4	0.5	1.9	2.7
Georgetown	6.9	5.7	0.1	0.4		0.2	0.4	0.3	0.9	0.3	3.6	0.8
Brampton	6.5	14.7	0.1	0.9	0.2	0.4	0.7	0.1	1.3	0.5	0.6	1.9
Orangeville	5.5	3.8	0.1				0.1	0.3	0.5	0.2	0.8	3.1
Toronto	4.1	3.2		0.2		0.1	1.2	1.3	0.6		0.2	0.6
Acton	2.0	2.5	0.1								1.9	
Hillsburgh	1.8			0.6		0.2	0.4	0.1	0.6			
Other	6.3	11.1		0.4		0.2	0.9	0.7	1.5	0.2	1.0	0.9

TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967 *(continued)*

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
Wellesley												
Wellesley	50.3	54.6	5.8	6.8	7.9	8.9	5.0	4.8	1.8	9.3		
Kitchener	29.2	29.4	3.0	0.9	1.6	0.7	4.0	4.5	2.3	0.5	5.0	6.8
New Hamburg	6.3	0.9	0.8	0.6	0.1		0.2	0.2	2.3	0.2	1.0	1.0
Baden	3.7			0.7			0.2		0.5		2.4	
Stratford	3.1	1.7	0.1	0.3			0.3	0.2	1.3		0.7	0.2
Waterloo	2.8	10.9	0.2	0.1	0.1	0.2		0.1			0.5	1.7
Milverton	1.1	0.9		0.4	0.1			0.1	0.5			
Other	3.3	1.6	0.1	0.2	0.2	0.2	0.3	0.1	1.3		0.4	0.3
Drayton												
Drayton	44.3	65.6	5.7	7.1	6.9	8.6	4.0	2.4	3.3	6.4		
Elmira	13.8	12.5	1.0	0.8	0.8	0.7	0.8	0.9	1.4	0.7	4.0	2.8
Kitchener	13.3	9.4	1.1		1.2	0.4	3.5	3.5	1.1	1.1	0.2	1.2
Palmerston	6.3[b]	0.0										
Listowel	5.2	1.6	0.3	0.4	0.2		0.2	1.3	1.1	0.2	0.7	0.7
Guelph	5.0	2.1	0.2	0.2	0.3		0.6	1.0	0.6	0.2	0.2	1.6
Arthur	2.6	2.1		0.2				0.1			1.6	0.7
Fergus	2.3			0.2					2.8	0.2		1.6
Moorefield	1.0	3.1	0.2	0.6	0.2	0.1						
Other	6.1	3.6										
Moorefield												
Listowel	35.5		2.8	1.5	2.3	0.6	3.1	5.2	3.3	5.6	4.4	6.5
Moorefield	27.2	89.2	5.5	3.9	6.8	8.7	2.0	0.4				
Palmerston	15.8		1.5	2.6	0.5		1.1	0.7	4.2	2.2	3.1	
Drayton	6.4	2.7	0.1	0.8	0.1	0.6	1.1	0.5	1.7	1.7		
Kitchener	4.7	2.7	0.2		0.2	0.2	1.6	1.9				0.6
Elmira	4.4	2.7		0.8	0.2		0.2		0.8		0.6	1.8
Other	6.1	2.7		0.4			0.9	1.3		0.5	1.9	1.1

TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967 *(continued)*

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
Rostock												
Stratford	45.9	35.7	1.0		0.2	5.7	5.0	7.6	2.0	4.3	10.0	10.0
Rostock	26.8	50.0	8.6	8.7	8.8			0.7				
Sebringville	12.1			0.7		1.9	0.7		6.0	2.9		
Milverton	10.3		0.5			1.9	2.4	3.7	1.4	1.4		
London	2.1						0.7			1.4		
Other	2.8	14.3										
Alma												
Alma	23.2	48.7	5.5	7.6	5.7		0.4	1.3	2.7			
Elora	22.6	7.7	0.8	0.3	2.1	4.3	1.7	0.2	0.9	6.4	5.0	0.7
Fergus	18.2	7.7	1.6		0.7	2.1	0.9	1.9		2.9	4.3	3.9
Guelph	12.5	10.3	1.1	0.6	0.6		3.2	3.0	1.8	0.7		1.5
Arthur	8.6			0.6	0.4	2.1	0.9	0.6	0.9			3.1
Elmira	4.8	10.3	0.4		0.1	1.0	0.6	0.4	0.9		0.7	0.8
Kitchener	4.5	7.7	0.7		0.1		1.8	1.9				
Waterloo	1.6	2.3			0.2	0.5	0.5	0.4				
Other	4.0	5.3		0.9	0.1			0.3	2.8			
Hawkesville												
Elmira	41.9	5.1	1.2	1.7	1.8	4.6	2.0	2.7	4.3	7.3	8.2	8.2
Hawkesville	18.6	43.3	4.1	6.3	4.2		1.5	1.5				
Kitchener	14.7	17.9	1.2	0.4	1.1	1.0	3.8	3.6		0.9	0.9	1.8
Waterloo	9.3	5.1	1.4	0.4	1.4		1.2	1.2	2.9		0.9	
St. Clements	5.4		1.1	0.8		4.6						
St. Jacobs	4.0				0.6		0.2		1.4	1.8		
Wallenstein	2.9	17.9	1.1		0.9			0.9				
Other	3.2	11.7		0.4			1.3	0.1	1.4			

TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967 *(continued)*

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
Caledon												
Orangeville	47.8		5.1	3.3	5.3	3.9	5.2	5.0	3.6	4.6	5.6	6.4
Caledon	17.0	44.4	2.4	5.0	1.9	3.9				3.9		
Brampton	11.4		2.0	0.8	1.7	0.8	0.9	0.8	1.8	0.8		1.8
Toronto	8.1	33.3				0.8	3.0	2.5			0.9	0.9
Oakville	3.4						0.9	0.8		0.8	0.9	0.9
Caledon East	2.7										2.7	
Guelph	2.6		0.8					0.8	0.9			
Streetsville	2.5	11.1										
Erin	1.8								1.8			
Other	1.7	11.2										
Carlisle												
Hamilton	41.0	47.6		2.7	0.6	0.6	8.8	9.3	5.3	1.4	4.1	8.3
Waterdown	23.8	6.0	5.1	1.2	7.1	2.2	0.5		0.6	3.3	3.7	
Carlisle	15.1	16.7	3.2	4.7	0.8	6.4						
Burlington	12.0	11.9	1.2	1.2	0.9	0.5	0.3	0.5	1.5	1.9	2.2	1.7
Guelph	1.2	1.2		0.3			0.2	0.1	0.6			
Other	7.0	16.6	0.5		0.6	0.3	0.2	0.1	2.0	3.4		
Puslinch												
Guelph	38.3	20.0	2.5		5.0	1.7	5.0	5.0	6.7	2.5	5.0	5.0
Kitchener	23.3	10.0		3.3		2.5	2.5	1.7	3.3	2.5	2.5	5.0
Puslinch	13.3	20.0	5.0	3.4	2.5			2.5				
Waterdown	5.0					2.5					2.5	
Burlington	5.0		2.5		2.5							
Morriston	4.2	30.0		3.3		0.8						
Hamilton	3.3						2.5	0.8				
Other	7.5	20.0				2.5				5.0		

TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967 *(continued)*

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
Wallenstein												
Elmira	60.6	16.7	3.0	7.8	3.5	8.9	4.4	3.7	1.7	8.9	10.0	8.8
Wallenstein	12.2	79.2	4.4		5.6			2.2				
Kitchener	11.8		2.0	0.6	0.6		4.1	3.3				1.3
St. Jacobs	4.4											
Listowel	3.5							0.2	3.3			
Linwood	3.2			0.6		0.7	0.7			1.1		
Waterloo	1.5		0.6				0.4	0.6				
Other	2.8	4.1		1.0	0.3	0.4	0.4		5.0			
Rothsay												
Palmerston[b]	22.4											
Drayton	15.1		1.1		2.8	3.9	0.7			6.7		
Moorefield	14.4	11.1	1.9	0.7	1.9	4.4	2.7	0.3	2.5			
Rothsay	11.1	22.2	4.4	6.7					2.5			
Arthur	8.6						3.0	0.3			2.0	3.3
Kitchener	6.2	22.2		0.7			1.7	1.4	2.5			
Alma	3.2			0.7					2.5			
Listowel	3.1	22.2						3.1				
Toronto	2.5							2.5				
Elora	1.7									1.7		
Other	11.7	22.3	2.6	1.2		1.7	1.9	2.4		1.6	8.0	6.7
Gadshill												
Stratford	75.3	57.9	6.4	2.5	8.3	10.0	8.1	8.3	5.0	6.7	10.0	10.0
Gadshill	9.7	26.3	2.2	7.5								
Tavistock	3.9						0.6			3.3		
Kitchener	3.6	5.3	1.1				1.1	1.3				
Wellesley	2.8	5.3	0.3						2.5			
Sebringville	2.5								2.5			
Shakespeare	1.7	5.3			1.7							
Other	0.6	0.0					0.2	0.4				

TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967 *(continued)*

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
Ballinafad												
Georgetown	47.7	33.3	4.4	3.8	4.4	8.3	0.2	4.4		7.8	8.6	5.7
Acton	16.1	6.7	1.2	2.5	1.2	1.3		0.7	4.3	2.2	1.4	1.4
Toronto	11.5	13.3			0.9		3.3	3.0	2.9			1.4
Brampton	11.4	20.0	1.5		0.9		3.6	1.1	2.9			1.4
Ballinafad	8.2	6.7	2.2	3.8	2.2							
Guelph	4.7	6.7	0.7		0.4		2.9	0.7				
Other	0.4	13.3				0.4		0.1				
Mono Road												
Brampton	42.0	20.0	3.6	2.0	1.9	5.0	0.8	4.0	8.0	3.3	3.3	10.0
Bolton	19.6	10.0	4.2		3.3	0.6	2.5	2.3		1.7	5.0	
Caledon East	17.0		0.6		4.7	4.4		0.7		5.0	1.7	
Toronto	7.2	10.0					4.2	3.0				
Mono Road	7.1	40.0	1.1	6.0								
Streetsville	6.5			2.0			2.5		2.0			
Other	0.6	20.0	0.5		0.1							
Salem												
Elora	49.2	12.5	2.9	2.6	6.9	7.2	4.9	2.6	4.1	9.5	6.0	2.5
Fergus	24.9	30.4	2.3	2.2	1.3	2.6	0.5	2.8	2.9	0.5	4.0	6.0
Guelph	12.1	14.3	1.8	0.4	1.3	0.2	3.0	2.6	2.4			0.5
Salem	6.9	32.1	2.6	4.3								
Kitchener	2.8		0.2		0.3		0.7	1.2				0.5
Waterloo	1.1		0.3		0.1		0.4	0.3				
Other	3.0	11.7		0.5	0.1		0.5	0.5	0.6			0.5
Cheltenham												
Brampton	69.2	56.3	5.5	6.3	7.6	8.3	5.5	3.2	7.5	8.2	99.1	8.2
Toronto	14.6	9.4	1.3	1.3		1.3	2.3	3.6	1.3	0.9	0.9	1.8
Snelgrove	2.5		0.6	1.3	0.6							
Cheltenham	2.4	12.5	1.2		1.2							
Galt	1.3								1.3			
Other	10.1	21.8	1.4	1.1	0.6	0.4	2.2	3.2	0.9	0.9		

TABLE 29

POWER INDICES FOR PERIPHERAL VILLAGES, 1967 *(continued)*

Interview Village	Summed Power Index	Work[a]	Groceries	Car Services	Hardware	Bank	Appliances-Furniture	Clothing-Shoes	Car Purchase	Doctor	Dentist	Lawyer
Meadowvale												
Brampton	47.5	11.1	4.9	3.6	4.8	6.2	3.3	2.8	2.7	5.8	6.4	7.0
Streetsville	22.0	5.6	3.8	2.7	2.9	2.1		0.8	2.7	3.3	3.6	
Toronto	20.4	27.8	1.0	1.8	1.7	1.0	6.7	6.4	1.8			
Cooksville	4.5					0.8			0.9	0.8		2.0
Malton	3.5	16.7		0.9	0.7				0.9			1.0
Meadowvale	1.0	27.8	0.4	0.6					1.0	0.1		
Other	1.2	11.0		0.4								

[a] The work column is the per cent of all full time employees reported by interview household for itself and for neighbours on each side; it is not included in the Summed Power Index.

[b] Data missing for individual goods and services.

Basically, the results for the individual power indices for the villages support results of previous workers (for e.g., Hill, 1969, Berry, 1967A). Thus, all but the most minimal villages dominate flows for at least one of the four lower order goods and services of car services, groceries, hardware, and banking. Of these four goods and services, groceries tend to show the greatest diversity in flow patterns indicating that, because of the frequency and overall value of grocery purchase, consumers do shop around among their spatially available nodes. (Similar results are noted in a study of the dispersed population in Iowa (Rushton, 1966).

For the higher order goods of appliances-furniture, clothing-shoes, and car purchase, none of the villages accounts for a majority of the shopping flows for all three, i.e. have a power index of 5.0 or greater on the individual scale of 10. Note that the cut-off point for listing an individual destination village was 1.0. New Hamburg, of the sample villages, shows up as being the village most meeting the needs of its inhabitants and, by extension, should be the most dominant over its trade area. Only for clothing-shoes does its major competitor, Kitchener, have a higher power index. Clothing-shoes and car purchase are clearly the highest order goods of those goods used here with the car purchase item tending to be purchased from the widest range of places. One problem with using car purchase, is that people migrating into a village bring their car with them. Also, the strength of an individual dealer can cause the destination village for car purchases to be well represented. For example, Schomberg for Bolton and Sebringville for Rostock.

Where the professional services of doctor, dentist, and lawyer are available in a village, use of the doctor's services most nearly obeys the basic central place postulate of using the nearest available service. Thus, for example, the people of Tavistock and Erin use the services of their local doctor almost exclusively. Similarly, when the professional services of a doctor are not available in the village, there is a tendency to concentrate in the next nearest place up the urban hierarchy. For dentists and lawyers, more choice seems to be exercised when the service is available in the village.

Results for the shopping flows for goods and services for smaller villages fit central place notions but should be treated with some caution because of the limited number of interviews from smaller villages taken in the one-in-three systematic sample. For employment flows, an attempt was made to obtain reasonably complete coverage by asking interviewers to give the work place of employed people living in the households on each side of them. Because of the limited sample size, separate analysis and measurements have been provided only for the villages where more than 40 interviews were taken.

Since no call-backs were attempted to maintain the accuracy of the sample, and since interviews were mostly conducted during the working week, questions arose on the possible bias inherent in the interview data. Thus, it could be postulated that a greater proportion of retired households (defined as having no employed person) would be interviewed. A comparison of Table 30, *Peripheral Villages - Basic Data on Households, 1967,* made up from data on the household interviewed plus the neighbour on each side and Table 31, *Peripheral Village Flows - Mean Distances Travelled, 1967,* shows, in fact, that the proportion of total households retired as based on total households is equal to, or greater than, that based only on the direct interview data. Hence, no bias appears to exist.

TABLE 30

PERIPHERAL VILLAGES - BASIC DATA ON HOUSEHOLDS, 1967

	Total No. Interviews	Total No. Neighbours Reported	Total Households Reported	% Total Households Reported Retired	Total No. Reported Employed
New Hamburg[a]	140	246	386	18.9	446
Bolton	100	172	272	25.1	261
Tavistock	66	117	183	32.8	162
Erin	67	114	181	35.9	157
Wellesley[b]	44	88	132	33.3	119
Drayton	44	87	131	37.4	96
Moorefield	18	35	53	49.1	37
Rostock	7	14	21	47.6	14
Alma	14	28	42	45.3	39
Hawkesville	11	22	33	9.1	39
Caledon	14	3	17	41.2	11
Carlisle	36	53	89	12.4	84
Puslinch	4	5	9	22.2	10
Wallenstein	9	16	25	16.0	28
Rothsay	6	10	16	68.8	9
Gadshill	6	11	17	11.8	19
Ballinafad	9	9	18	16.7	15
Mono Road	6	3	9	11.1	10
Salem	20	38	58	25.9	56
Cheltenham	11	17	28	25.0	32
Meadowvale	15	7	22	36.3	18

[a] Villages are ranked according to their summed power index.

[b] A Waterloo area regional government study based on an assessment question, 1967, on place of work lists 211 employed for Wellesley and 51% of those employed as working in Wellesley. The comparative percentage derived from the interviews was 55%.

TABLE 31

PERIPHERAL VILLAGE FLOWS - MEAN DISTANCES TRAVELLED, 1967[a]

	All Interviews		New Hamburg		Bolton		Tavistock		Erin		Wellesley		Drayton	
	Means	Deviations	Means	Deviations	Means	Deviations	Means	Deviations	Means	Deviations	Means	Deviations	Means	Deviations
Family size	3.71	1.95	3.88	1.88	3.93	1.92	3.62	1.94	3.63	2.15	3.64	2.02	3.02	1.58
Children under 16	1.44	1.73	1.76	1.77	1.78	1.73	1.12	1.70	1.39	1.93	1.11	1.53	1.00	1.38
Proportion households retired	0.27	0.44	0.19	0.39	0.24	0.43	0.30	0.46	0.33	0.47	0.32	0.47	0.34	0.48
Distance to work - male head	6.68	11.05	4.51	5.84	9.76	9.19	3.47	5.88	10.19	17.20	5.75	7.78	9.02	21.38
Distance—Groceries	3.45	5.07	2.31	3.80	2.60	5.12	2.39	3.87	3.25	5.83	4.30	6.67	2.89	5.33
—Hardware	2.87	4.59	1.48	2.54	2.13	4.23	1.26	1.56	1.58	3.43	2.55	4.94	3.36	7.02
—Bank	3.43	5.55	1.44	2.37	3.41	5.88	2.41	3.79	3.25	8.80	2.07	3.85	2.48	5.76
—Car services	3.89	6.04	2.21	4.10	4.64	6.80	2.67	4.06	4.33	7.91	4.55	6.08	3.77	6.07
—Car purchase	10.85	16.02	5.93	12.72	14.56	19.23	9.12	17.21	13.39	21.86	13.09	14.12	not calculated	
—Appliances-furniture	9.23	11.23	5.07	5.72	9.68	9.06	2.48	5.81	12.73	18.14	8.89	8.55	16.16	17.43
—Clothing-shoes	11.97	11.46	7.33	6.12	11.78	8.85	9.59	13.61	17.81	20.04	10.66	8.52	18.23	11.38
—Lawyer	10.68	11.21	3.79	5.31	10.42	10.13	12.56	16.51	15.76	16.05	15.68	5.01	21.77	12.97
—Doctor	5.34	6.84	4.49	5.11	5.24	6.87	1.58	2.88	4.64	10.33	1.98	3.79	7.84	9.90
—Dentist	8.63	8.37	5.92	6.25	3.13	5.82	12.27	12.54	12.16	11.22	15.14	5.38	14.82	5.64
—Place used more frequently than 5 years ago	3.08	7.80												
—All goods & services	7.03													

[a] Since a missing data option was not usable at the time of this factor analysis output, variables on which an interviewee gave no answer (i.e., zero distance) would tend to have lower means. Variables minimally affected (i.e., a few non-responses) are car purchase, appliance-furniture, lawyer, dentist and the only variable seriously affected is place used more frequently than five years ago where about three out of four responses are no change, i.e., zero distance.

For the six villages in which more than 40 interviews were completed, comment is made on average distance travelled to procure goods and services. Note that distance to the home village is calculated as one mile. Table 31, *Peripheral Village Flows - Mean Distances Travelled, 1967,* provides these data along with means and deviations on three family characteristic variables later used in a relatively unsuccessful multiple regression model. Immediately evident are the high standard deviations. This problem results because often a dominance of trips to the village, or one centre, occurs for a particular good. Possibly a transformation of the data should be tried, but time and finances did not permit such checking.

Using the assumption implicit in central place theory that lower order goods and services should be available nearer at hand than higher order goods and services, the ranking of goods based on mean distance travelled could be derived. First, for all interviews, the goods rank in order as follows: hardware, bank, groceries, car services, appliance-furniture, car purchase, clothing-shoes; the ranking for the professional services supports the conclusion stated above that doctor's services tend to be more of a low order good than lawyer or dentist. Respectively, the means are 5.34, 10.68 and 8.63 miles. Thus, doctor's services would rank behind car services. These results again basically support central place theory.

Villages on the periphery of the study area and the periphery of the basic urban corridor, like Drayton and Erin, have increasingly higher mean distances for most goods and services. One reason, of course, is that certain goods and services, e.g., dentist are not available in the village or are only minimally available. For instance, mean distances travelled for clothing-shoes, furniture-appliances, and lawyers appear to increase as the summed power index of the village lessens. These tentative conclusions have not been quantitatively tested because of the relatively small number of villages, but will be tested when similar data for about 15 villages in the Hamilton-London corridor have been analysed.

Using these results, derived for randomly selected peripheral villages, the flows for shopping goods and services is basically a regular one and should, therefore, be predictable with a high degree of accuracy. Shopping flows from non-peripheral villages, that is, villages clearly within the orbit of a larger city, should pose even fewer problems of prediction.

Employment Flows

One of the two basic hypotheses under investigation was that by interviewing in peripheral villages, not only could flow characteristics be established for various goods and services, but that the shopping and employment sheds of the cities could be determined. The method involved of using a systematic sample and working in a village node is quick and economical because of ease of sampling and the spatial concentration of the sampled population. One interviewer can complete 15 to 20 interviews per day.

But back to the question: can shopping and employment sheds be readily outlined? Based on Figure 22, *Shopping Flows,* and Figure 23, *Employment Flows,* the answer appears to be yes, if one modification to the approach used here is made. That modification is to interview all, or possibly carefully selected (for spatial reasons),

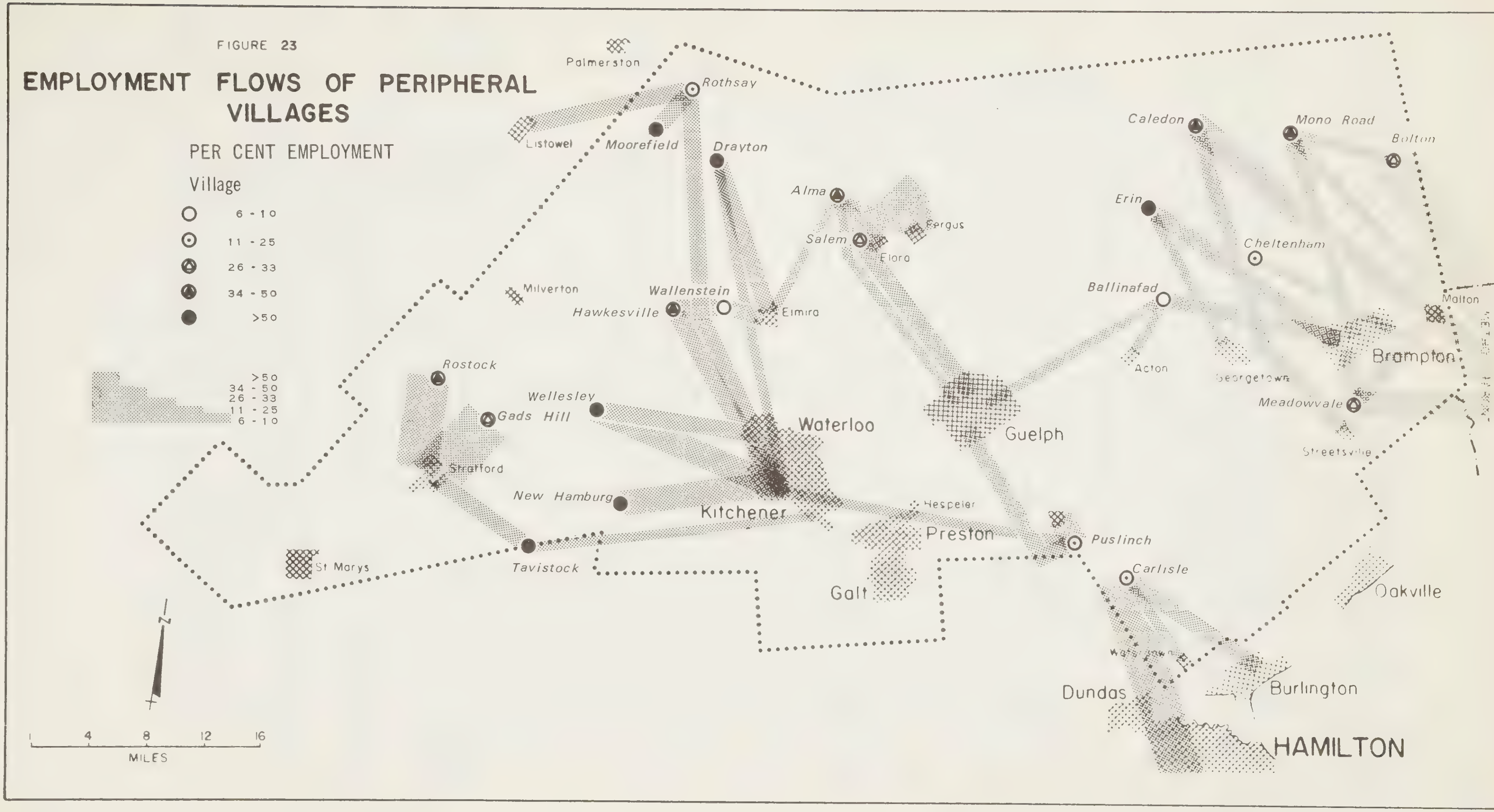


FIGURE 23

EMPLOYMENT FLOWS OF PERIPHERAL VILLAGES

peripheral villages. For example, the shopping break between Guelph and Hamilton-Burlington clearly lies somewhere between Puslinch and Carlisle but where the boundary falls in the Campbellville area is uncertain. I further suggest that this approach provides a simple and valid method for initially testing whether or not townships should belong to one regional government area or another. For example, if shopping flows of village residents are considered important, then Erin Township, as indicated by the shopping flows of Erin village, belongs with Wellington County, not with Peel or Halton, as has been proposed. However, if employment flows are used, then some differences result. Erin still accounts for over 50 per cent of its employment flows but the dominant outflow is east to Brampton.

Generally the employment shed pattern appears to be less stepwise hierarchically than does the shopping shed pattern. Possibly a modified gravity model could predict the greater flows for employment than for shopping attracted by the larger centres of Toronto and Kitchener. Mean distances travelled by the male head to the work place based on the 647 interviews is 6.7 miles and again appears to increase with some exceptions, like Bolton, as the summed power index of the village decreases. Thus, the sixth village on the basis of the summed power index, Drayton, has a mean of 9.02 miles, as compared with 4.51 miles for New Hamburg and 3.47 miles for Tavistock. Here also quantitative tests need to be applied using some form of gravity model which puts together attracting force and distance. For example, the respective work flows from Tavistock to Stratford and Kitchener may well be predictable. When the data for the Hamilton to London villages are compiled, such a model will be attempted.

Association of Employment and Shopping Flows

The second basic hypothesis specifically investigated for these flows was that employment flows would tend to be associated with shopping flows and, from a causal standpoint, might, in fact, generate flows. Both factor analysis and multiple regression analysis were utilized in testing this hypothesis. The Table on mean distances travelled (see Table 31) provides basic means on the variables used for all interviews and for the six villages in which over 40 interviews were taken.

The Factor Analytic Result

The factor analytic technique was applied to village interviews for two purposes. First, the question was asked: given the measured variables available, would the households interviewed group into a meaningful and interpretable structure or are flows too complex in structure to really reduce to a few underlying dimensions? Second, would the mathematical technique pick out variables which would cluster into factors related to the hypothesized relationship between employment and shopping flows?

The results, while not conclusive, did indicate some hypotheses to follow up. Initially 35 variables were used measuring the distance to work place for male head and first female worker and the first and second choice place for the 10 shopping goods and services. Three family characteristics—size, number of children under 16, and retired or not—were included; so was a type of work variable for both male and female. The second choice, shopping place, the type of work and female work place were deleted

after an initial run because of their limited contribution to the correlation matrix. The final run was then taken on the fifteen variables listed on Table 32 entitled, *Peripheral Village Flows - Correlation Matrix.*

Both in the factor analysis and in the subsequent multiple regression analysis, distance is used in two ways simultaneously. First, it is used as a surrogate measure for the destination places of the flows. Given the fact that distances are not the same to any destination place, the main problem in this surrogate use is that distances may be similar enough among several places for a given flow so that grouping of destination places results. If so, then an argument can be made that, in fact, the spatial nodal system, in which this possibility occurs, has sufficiently similar opportunities that such results reflect perceived realities of the spatial nodal system.

On Tables 32 and 33 are presented the values of the factor analysis correlation matrix and the variable loadings for the four factors derived from the factor analysis, based on all 647 interviews taken from all 21 randomly selected peripheral villages. Using the eigen value cut-off point of 1.0, only four factors were derived; these four factors account for 52 per cent of the variance.

A look at the correlation matrix suggests why only about one half of the total variance is explained. Many variables are almost uncorrelated with each other. However, given 647 observations (interviews) an r value of 0.11 is significant at the one per cent level. Thus, over half of the possible pairs are significantly correlated statistically, even though values are low. Further work needs to be done on these flow data, for instance, transformations of the data might increase the correlations but such transformations were not tried here. Rushton has noted that a real problem in using regression models on consumer travel is the problem of linearity, (Rushton, 1966). An example would be a village like Erin which provides most goods for its inhabitants, and, thus, has a high power index; but it does not have the services of a dentist and lawyer. Thus, most travel distances are 1 (i.e. to Erin itself), while distances for lawyer and dentist will be much higher leading to skewness in the distribution.

From the correlation matrix, some support is derived for the hypothesis that interrelations exist between the shopping and the employment flows. Except for the already previously noted highest order goods and services of car purchase, lawyer, and dentist, all other shopping goods and services used here as independent variables are significantly related (1 per cent level), though the highest r value is only 0.25. Further analysis is needed with a necessary first step being separate analyses of the internal village flows and the external village flows.

From the factor analysis output, four readily identifiable factors occur. Factor loadings of 0.30 or −0.30 and greater are used in an attempt to derive maximum information from this exploratory application of factor analysis to village flows. By accepting these lower variable loading values instead of the more usual 0.50 or −0.50 values, all variables are included in at least one factor.

TABLE 32

PERIPHERAL VILLAGE FLOWS - CORRELATION MATRIX

VARIABLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Variable															
1. Family size	1.00														
2. Children under 16	0.90*	1.00													
3. Retired or not	–0.55*	–0.46*	1.00												
4. Male head - distance to work	0.26*	0.25*	–0.36*	1.00											
First Choice Shopping - Distance															
5. Groceries	0.07	0.04	–0.15*	0.17*	1.00										
6. Hardware	0.06	0.07	–0.13*	0.16*	0.35*	1.00									
7. Bank	0.09	0.09	–0.11*	0.25*	0.21*	0.30*	1.00								
8. Car services	0.16*	0.15*	–0.19*	0.20*	0.15*	0.21*	0.27*	1.00							
9. Car purchase	0.04	0.04	–0.08	0.09	0.12*	0.04	0.16*	0.21*	1.00						
10. Appliances-furniture	0.10	0.13*	–0.17*	0.20*	0.22*	0.22*	0.16*	0.15*	0.16*	1.00					
11. Clothing-shoes	0.01	0.02	–0.12*	0.20*	0.11*	0.14*	0.13*	0.12*	0.12*	0.42*	1.00				
12. Lawyer	–0.00	0.00	0.01	0.10	0.09	0.01	0.11*	0.06	0.16*	0.33*	0.31*	1.00			
13. Doctor	0.00	0.03	–0.07	0.12*	0.11*	0.21*	0.27*	0.18*	0.04*	0.23*	0.18*	0.14*	1.00		
14. Dentist	0.07	0.02	–0.09	0.07	0.08	0.10	0.10	0.07	0.18*	0.20*	0.24*	0.36*	0.21*	1.00	
15. Place used more frequently than five years ago	0.12*	0.10	–0.16*	0.11*	0.06	0.04	–0.05	0.14*	0.07	0.21*	0.24*	0.18*	0.03	0.16*	1.00

Significance:

At 645 degrees of freedom based on the number of interviews available, a coefficient of correlation of 0.11 or greater is significant at the 1 per cent level.

The asterisk indicates variables significant at the 1 per cent level. Sixty-six of 105 pairs are thus significantly related statistically, even though the values are low in magnitude.

TABLE 33

PERIPHERAL VILLAGE FLOWS - FACTOR ANALYSIS VARIABLES

Variable	Variable Loadings All Interviews Analysis				
	Per Cent Communality Explained	Factor 1	Factor 2	Factor 3	Factor 4
1. Family size	87.3	−0.93	0.01	−0.03	0.06
2. Children under 16	81.8	−0.90	0.01	−0.02	0.05
3. Retired or not	56.7	0.72	−0.13	−0.17	−0.01
4. Male head - distance to work	33.6	−0.41	0.17	0.36	0.07
First Choice Shopping - Distance:					
5. Groceries	41.5	−0.05	0.12	0.63	−0.05
6. Hardware	57.9	−0.04	0.05	0.75	−0.07
7. Bank	54.4	−0.06	−0.07	0.59	0.43
8. Car services	40.6	−0.22	−0.02	0.37	0.47
9. Car purchase	58.2	−0.03	0.10	−0.01	0.76
10. Appliances-furniture	53.1	−0.10	0.64	0.33	0.02
11. Clothing-shoes	53.4	−0.00	0.70	0.21	0.02
12. Lawyer	54.0	−0.08	0.65	−0.05	0.33
13. Doctor	29.1	−0.05	0.20	0.44	0.23
14. Dentist	42.9	−0.01	0.51	−0.02	0.41
15. Place used more frequently than 5 years ago	38.3	−0.19	0.58	−0.05	−0.11

Variance Explained:

Total 52.2%

Factor 1 - Family structure and work trip	16.6%
Factor 2 - Mobility for higher order goods and services	13.6%
Factor 3 - Mobility for lower order goods and services	13.1%
Factor 4 - Mobility and mixing of higher and lower order goods and services	8.9%

Factor 1, All Villages: Family Structure and Work Trip: This factor is clearly dominated by the three family characteristic variables which follow normal relationships. Thus, the larger the family, the more children expected under 16 years of age and the less the possibility of being retired. Also, family size and children under 16 are the only variables having much more than half of their communality explained, i.e., the proportion of the total variance of the variable explained by the four factors derived from the factor analysis. Also, loading most highly on Factor 1 at -0.41 is distance to work for the male head. This relationship suggests that larger families with more children tend to travel further to work. Such a hypothesis, of course, needs much more detailed testing. This relationship also showed up in separate factor analyses tried on individual villages and appears to merit further investigation.

Factor 2, All Villages: Mobility for Higher Order Goods and Services: Five variables load with the same sign at 0.51 or higher on this factor. Two of the variables are the higher order goods of appliances-furniture and clothing-shoes; another two are the higher order services of lawyer and dentist. These four higher order goods and services occur least frequently in the villages. Consequently, the mean distances travelled for these higher order goods and services is greatest of the 10 goods and services investigated and ranges from 8 to 12 miles, while the mean distance travelled for all goods and services is approximately 7 miles.

Interrelated with this factor is the variable asking about place shopped in more frequently. About three out of four interviewees responded to this question with a no change answer; hence, the actual mean distance value is much too low. However, the relationship with the higher order goods is not affected. Since this variable loads only on this factor, it points out that increasing mobility to changes in the consumer travel pattern is mainly applicable only to higher order goods and services.

Factor 3, All Villages: Mobility for Lower Order Goods and Services: Of the seven variables loading significantly (all positively) on this factor, which explains about the same amount of variance as Factor 2, five are the lower order goods and services of groceries, hardware, bank, car services and doctor. Also, loading at 0.30 or higher on this factor are distances travelled for appliance-furniture and for work. Direct observation of interviews, village by village, shows that when appliances-furniture are available in a village, they tend to have a power index value between that of the lower order goods and the higher order goods. Also, these goods tend to be at least minimally available in most villages, if not in separate establishment, then through a hardware store. Any suggested explanation of the relationship to Factor 3 of the other variable, male head distance to work while in the direction of the hypothesis put forth on work-shopping linkages is only tentative. Two possibilities exist: (1) These lower order goods are mainly procured in the village and in many villages over half the employment flows are internal—thus the relationship; or (2) low order goods tend to be purchased as an offshoot of the work trip. Note also that the mean distance for the work trip (6.7 miles) is greater than that for the lower order goods and services (2.9 to 5.3 miles). Again, separate analyses of the internal and external flows are needed to clarify the tentative explanation.

Factor 4, All Villages: Mobility and Mixing of Higher and Lower Order Goods and Services: This factor is more difficult to interpret than other factors but is a reflection

of the complex flows noted in the distance to car purchase place variable, which loads highly, but only on this factor. The linkage between car purchase and car services can be expected, since car services include maintenance of the car and such linkages were noted in the table on the power indexes (see Table 29). Thus, for instance, Schomberg is used by a number of people in Bolton, both for car purchase and car services. Why the low order service of banking should be associated is less clear. Possibly the relationship develops in villages which dominate both the car purchase good and banking; for example, New Hamburg has power indices of 7.0 for car purchase and 9.2 for banking and contributes 140 of the total 647 interviews.

Plausible suggestions for the association between consumer mobility, car purchase, lawyer and dentist can be made. First, these three variables are all higher order; second, they are apt to be procured from a nearby larger place, even when available in the village; third, consumer choice for all three goods seems to be complex and irregular involving considerable personal preference.

This factor analysis application to shopping and employment flows for all villages has shown that four underlying dimensions summarize about one-half of the total variance of the 15 variables on shopping, employment and family characteristics. Generally, the same dimensions showed up in the several factor analysis tried on the larger individual villages. In an attempt to more specifically test the hypothesis that place of work influences place of shopping for villages, above and beyond the central place effect, a regression analysis is next undertaken.

The Multiple Regression Results

The hypothesis being tested states that place of work influences place of shopping, above and beyond the central place effect. Also inserted, as independent variables in this regression analysis, were the three family characteristics. These three variables were included as independent variables because the first factor in the factor analysis clustered mobility for work with the three family characteristics. The multiple regression model then consists of the distance travelled to first choice place, with each of the 10 shopping goods and services, in turn, being treated as the dependent variable and distance to work place, family size, children under 16, and retired or not, as the independent variables. Additional family characteristics would, of course, be useful as independent variables. Also, retired households (no employed person) and working households should be analysed as separate subsets. Hence, the analysis on associated mobility for shopping and employment presented here deals with only a few aspects of a complex behavioral syndrome.

Table 34 presents the multiple coefficient of correlation results for all interviews and the six villages in which 40 or more interviews were taken. Of the 68 multiple regression runs reported, distance to work place of male head entered first in 35 runs, retired or not retired in 19 runs, number of children under 16 in 8 runs, and family size in 6 runs.

TABLE 34

MULTIPLE COEFFICIENTS OF CORRELATION - SHOPPING AND EMPLOYMENT MOBILITY[a]

Shopping Goods or Service[b]	All Interviews	New Hamburg	Bolton	Tavistock	Erin	Wellesley	Drayton
Groceries	0.199**	0.244	0.219	0.671**	0.114	0.504**	0.154
Hardware	0.179**	0.341**	0.196	0.280	0.296	0.371	0.287
Bank	0.302**	0.256	0.330*	0.377*	0.393*	0.320	0.297
Car service	0.248**	0.399**	0.303	0.469**	0.314	0.297	0.205
Car purchase	0.107	c	0.150	0.320	0.132	0.052	c
Furniture-appliances	0.238**	0.350**	0.334*	0.219	0.264	0.562**	0.636**
Clothing-shoes	0.220**	0.370**	0.369**	0.151	0.233	0.513*	0.425
Lawyer	0.114	0.223	0.217	0.105	0.237	0.351	0.283
Doctor	0.148**	0.196	0.212	0.380*	0.223	0.289	0.418
Dentist	0.117	0.247	0.162	0.328	0.375*	0.614**	0.266

[a] Underlining of the coefficient of correlation indicates that distance to work place entered the regression first. The program used is the B.M.D. stepwise multiple regression program.

[b] * Significant at the 5% level, ** significant at the 1% level. Because of different degrees of freedom values at or above which significance results change throughout the table.

[c] Not calculated.

For the multiple regression runs on all 647 interviews, the correlation coefficients are all significant at the one per cent level, except for car purchase, lawyer and dentist. However, even the highest coefficient of determination R^2 would "explain" less than 10 per cent of the total variance. Thus, while a statistically valid relationship holds, given the large number of observations, its empirical value is dubious. Theoretically what may be inferred is that the spatial system, within which the village households meet their employment and shopping needs, is a system with many possibilities for meeting individual preferences. This inference fits the type of reasoning used by Rushton in this study. *Spatial Patterns of Grocery Purchases by The Iowa Rural Population* (Rushton, 1966).

From the analysis of the power indices, it was evident that, while the patterns fitted central place notions, some variation still existed in the spatial pattern of shopping flows between villages. On the power indices table (Table 29) the per cent of work flows to destinations are also presented. The work flows are compiled from destinations reported by the household interviewed, both for itself and for both immediate neighbours, and indicate considerable spatial variation. Hence, multiple regression analyses were undertaken for the six villages from which 40 or more interviews were available.

The results from Table 34 indicate again that flow associations are complex. Furniture-appliances runs were significant in four of the six villages, banks and clothing-shoes in three of the six, groceries, car services and dentists in two of six, and hardware and doctors in one of the six villages. Car purchases and lawyers were not significant.

For all but four of these significant results, distance to work-male head entered the stepwise regression model first. The exceptions were dentists for Erin and Wellesley and clothing-shoes for Wellesley, and furniture-appliances for Drayton. Here the first variable entering was retired or not, except for Erin—dentist, where the number of children under 16 entered first.

Such results indicate the overall complexity of the shopping-employment flow patterns, while giving some evidence that the work place affects shopping patterns. For instance, Drayton has the retired or not variable entering first for seven of the 10 shopping variables; at the same time, it has 37 per cent of its households listed as retired (Table 30) but accounts for 66 per cent of its employment flows. Interestingly, of the six villages from which 40 or more interviews are available, the per cent of households retired increases as their summed power index decreases. This relationship holds for all villages having a summed power index of 20 or more, i.e., the lower the index, the higher the per cent households retired, suggesting a hypothesis of village decline. Clearly, many specific hypotheses are still open for investigation in these data on shopping and employment flows.

PART VII

CITIES AND TOWNS AND FLOWS OF MESSAGES

In outlining the sub-system elements of the interactional sub-system of the urban system, four sub-systems of flows were identified, flows of people, flows of traffic, flows of goods, and flows of messages and ideas. In Part VI, data on two elements of the flows of people, the movement to work and the movement for goods and services, were presented for peripheral villages in the urban system of the Toronto to Stratford area. The interactional sub-systems of flows of traffic and flows of goods are not pursued further in this report because of lack of testable data, which partly results from cost, effort, and time constraints. Some initial analysis of traffic flows in southwestern Ontario is available for 1961 (Russwurm, 1964).

The lack of results here again points up the need to consider further research in this area regardless of the cost in money, time and effort involved. Our understanding of the locational sub-system of the urban system is reasonable and is steadily improving with a useful theoretical base available from locational and central place theory. On the other hand, while we know that flows begin between the minor individual nodes of households or households and individual business nodes and other nodes, we do not know how the cumulative increase in quantity and complexity of such flows rearranges and reorganizes the locational sub-system. Hence, the real research need in an analysis of urban systems is work on flows. Recently, Simmons has presented a similar argument (Simmons, 1968). Such research is of particular significance in Southern Ontario, at present, because of our rapidly developing cities and the current reorganization of local government.

In this part, some limited results are presented on the fourth flow sub-system identified—the flows of messages and ideas. Here, the flows are restricted to three of the six main media for sending messages—telephone, mail, and newspaper. No data have been gathered on radio, television, or person-to-person flow of messages, nor are the data used for telephone, mail and newspaper flow nearly as complete as wished.

Telephone Flows

Without doubt, among the major interactional elements of urbanization are the communication linkages provided by the telephone network. It has been pointed out, in previous research, that telephone flows are probably the best single index of socio-economic interaction between urban places (Pfouts, 1962, Nystuen and Dacey, 1961, Green, 1955). They provide a worthwhile measure of both the social and economic interaction of people separated by space, especially at the interurban level.

The telephone data used were provided by Bell Telephone, and consisted of a ten day sample of both to and from toll calls between toll centres in both the Toronto-Stratford and the Hamilton-London corridor areas for 1966. Somewhat less complete data were analysed for the Hamilton to London area, 1957 and 1962, (Russwurm, 1964) and will be compared with the 1966 results. The data, thus, are valid for toll calls only; it may under-represent corridor message flows because calls on

trunk lines provided for major customers by Bell are not included. Such lines, it is expected, would primarily be operating between the cities and especially with Toronto and it is expected would strengthen the corridor effect.

The omission of non-toll calls does not appear to be a problem, since research in the Grand River Triangle of cities has shown that such calls are reasonably predictable by a simple gravity model (Sellner, 1969). Sellner's results for the urban places comprising the Grand River Triangle gave a multiple correlation coefficient of 0.85. Thus, about two-thirds of the variation in calls between the Grand River Triangle of cities is explained by distance and population parameters. His gravity model used the number of calls as the dependent variable, and population of outflow city, population of inflow city and distance between the cities as the independent variables.

The stages of analysis of the telephone data are as follows. A simple gravity model multiple regression approach for 1966 is first taken for flows in the combined urban corridors of Toronto-Stratford and Hamilton-London. Combined corridors are used so that corridor flows and cross-corridor flows can be compared to test the hypothesis that corridor flows could be higher. Note the inclusion of the town of Orangeville on the northern periphery of the Toronto-Stratford corridor area as a counterpart to Tillsonburg on the southern periphery of the Hamilton-London corridor area. This hypothesis operationally means that the gravity model multiple regression results should be higher for the cross-corridor flows. That is, the population distance variables are expected to underestimate the corridor flows. This hypothesis is tested by analyzing residuals from the regression of flows between interacting pairs of places.

The Gravity Model Multiple Regression Results: Combined Corridors

The model used here is the same as that used by Riddell in his analysis of long distance telephone messages for 1962 in southwestern Ontario (Riddell, 1965). The dependent variable is the logarithm of the calls between pairs of places. To and from calls are both used, rather than only total calls between places. The independent variables are, X^1, the distance in miles between places, X^2, the population of the outflow or sending city, X^3, the population of the inflow or receiving city. The independent variables are also all transformed by logarithms (Base 10). For a thorough discussion of the application of gravity models see Olssen and Isard, (Olssen, 1965, Isard, 1960).

The multiple correlation coefficient R^2 based on 132 interacting pairs of places in 1967 was 0.90. Hence, over four-fifths of the variation in telephone calls between interacting pairs of places in the combined corridor areas is explainable mathematically by the population distance interaction. These results are almost identical to Riddell's, whose R^2 was 0.91. These results are significant at the 0.001 probability level. This gravity model then has a high level of predictability for the combined corridors.

From the stepwise regression results, it is worth noting that variable X^1, the sending population, entered the equation first with a correlation of 0.52 followed by variable X^2, the receiving population, which raised the correlation coefficient to 0.75. Thus, distance entered last but contributed another 0.15 leading to the final multiple correlation coefficient of 0.90. Each of the variables contributes well to the correlation because correlations between each other are less than 0.10.

The resultant multiple regression equation and Riddell's, for comparative purposes, are given below.

Combined Corridors

Log calls = 0.84 + 0.77 log sending population + 0.73 log receiving population − 1.80 log distance.

Riddell - Southwestern Ontario

Log calls = −4.12 + 1.07 log sending population + 1.10 log receiving population − 2.13 log distance.

These equation coefficients pose some questions worthy of further study. For the combined corridors the distance exponent value is 0.33 lower at −1.80 than was Riddell's for all of southwestern Ontario. Thus, the effect of distance appears to be less in the corridor areas. Further evidence supporting this contention is the distance exponent value of −0.85 derived by Sellner for the Grand River Triangle (Sellner, 1969). These results suggest that the friction of distance may be a stepwise function related to different threshold intensities of interaction.

Similar results occurred for the population variables with lower beta values for the combined corridors with coefficients of 0.77 and 0.73 where Riddell's were 1.07 and 1.10. However, Sellner obtained the same population coefficients of 1.10 as did Riddell. The hypothesis to be tested for the corridors, then, is that the friction of distance is less but the population attraction may also be less. In other words, the further apart places are in physical miles and/or in accessibility, the more important is the population mass in increasing interaction and the more important is the distance in retarding interaction. Correlation results for gravity models could thus be similar, though underlying processes related to population and distance could be different, depending upon the spatial scale of the analysis.

The relationship between population and distance was further investigated by testing the per capita outflow of long distance telephone calls and the logarithm of distance. Underlying this test is the notion that, the higher up the urban hierarchy a place is the greater will be the per capita outflow of messages, other population-distance factors being constant. If so, then increased per capita outflow in a gravity model would reduce the friction of distance effect. Theoretically, and from a process standpoint, the increased intensity of messages postulated for places further up the urban hierarchy results because these places organize the urban system; compare to university administration, where many more messages are required from a dean's office than from a professor's office.

Outflow calls per 1,000 population to Metro Toronto are generally higher than to other places (Table 35). Of the 11 places, other than Toronto, five, Kitchener, Brampton, Orangeville, Hamilton and London, had their highest outflow per 1,000 sending population to Toronto. Of the remainder, Guelph and Stratford directed their highest message intensity to Kitchener; Woodstock and St. Thomas to London; and Tillsonburg to St. Thomas. Telephone messages are, thus, directed up the urban

TABLE 35

LONG DISTANCE TELEPHONE FLOWS[a] PER 1,000 SENDING POPULATION, 1966

TORONTO-STRATFORD CORRIDOR[b]

To	Toronto	Kitchener[c]	Guelph	Stratford	Brampton	Orangeville
Toronto		29	7	3	42	4
Kitchener	307		173	73	25	13
Guelph	284	415		13	65	47
Stratford	229	386	27		12	3
Brampton	1,768	70	98	6		98
Orangeville	1,332	157	447	18	540	

Mean: Including Toronto 223; excluding Toronto 111

HAMILTON-LONDON CORRIDOR

To	Hamilton[d]	London	Brantford	St. Thomas	Woodstock	Tillsonburg
Hamilton		10	40	3	6	2
London	35		13	87	36	14
Brantford	224	21		6	57	24
St. Thomas	43	954	15		38	82
Woodstock	157	788	244	67		230
Tillsonburg	118	574	210	3,216	513	

Mean: Including Tillsonburg 261; excluding Tillsonburg 148

ACROSS CORRIDORS

To	Hamilton	London	Brantford	St. Thomas	Woodstock	Tillsonburg
Toronto	59	7	6	2	2	1
Kitchener	112	63	53	5	25	4
Guelph	112	32	20	4	8	2
Stratford	48	344	16	11	94	4
Brampton	213	12	12	4	6	2
Orangeville	79	45	17	3	13	5

To	Toronto	Kitchener	Guelph	Stratford	Brampton	Orangeville
Hamilton	338	57	18	4	24	2
London	176	36	7	35	5	1
Brantford	216	149	17	7	8	1
St. Thomas	181	28	9	13	8	1
Woodstock	433	244	35	150	19	5
Tillsonburg	247	20	86	21	14	1

Mean: Across corridors 56; excluding Tillsonburg and Orangeville 77

Grand Mean: Including Toronto 94, excluding Toronto 121.

[a] Calls are toll calls to and from for a 10 day sample.

[b] Data were inadvertently omitted by Bell Telephone for certain places; because of the need to complete this report as soon as possible the analysis was completed without the missing flows. The general results are not really affected by the missing data; an analysis using complete data will be undertaken later.

[c] Includes Waterloo and Bridgeport.

[d] Includes Burlington and Dundas.

hierarchy since Toronto is supreme and London and Kitchener rank next in influencing a large external area. Hamilton is in the same level but concentrates its messages on its larger internal population; also much of its area of external influence is south towards Lake Erie.

Table 35 also offers strong evidence supporting a higher level of interactions along the corridors than across them. Complete data were used earlier in the Hamilton-London corridor for 1962 and provided similar evidence for the increased strength of corridor interactions. No doubt, the data missing on the cities of Galt, Oakville and Georgetown will strengthen the partial results given here.

When the calls per 1,000 sending population are compared for interacting pairs, the means are 223 for the Toronto-Stratford corridor, 261 for the Hamilton-London corridor and only 56 for interacting pairs across the corridors. Even when Toronto is excluded, the results still conclusively show the higher intensity of telephone message flows along the corridors. These data are not adjusted for population mass; earlier results for 1962 in the Hamilton-London Corridor (Russwurm, 1964), where population adjustments were made, still supported the higher intensity of telephone message interactions along the corridor, as compared to across the corridor. An additional worthwhile analysis would compare calls per 1,000 receiving population.

Excluding Metro Toronto interactions, the mean value is 94 calls per 1,000 sending population using interacting pairs of places for the combined corridor places. When Metro Toronto is included, this mean value increases to 121 calls per 1,000 sending population over the 10 day sample period. From Table 35, it is clear that the higher intensity interactions for Toronto result, not from the calls per capita sent out from Toronto, but from the other places sending to Toronto. Thus, the flows up the urban hierarchy are again noted.

Only actual outflow calls per 1,000 sending population are used, since a plotted scatter diagram was inconclusive, except to point out the high interactions of several places with Toronto. Possibly a logarithmic transformation would be worthwhile for the per capita value. Log values of distance, however, were used as the independent variable in the simple linear regression and correlation.

The index of calls per 1,000 sending population with log of distance as the independent variable gave a correlation coefficient of –0.323 (significant at the 0.05 per cent level). This correlation is higher than that obtained between actual calls sending population and the log of distance where the correlation was not significant (–0.222). With a distance exponent value of only –0.34 for per capita calls, limited evidence thus exists that the index of per capita outflow calls does help to reduce the friction of distance effect in a simple gravity model. In the present study, the location of Metro Toronto at one end of the study area may be a distorting factor. As the interactions indicate here, and also for mail and newspaper messages, interactions with Toronto seem to be at a higher place and should probably be analyzed separately.

The impact of the dominance of Toronto in telephone calls per 1,000 sending population was further tested in an additional regression run with Toronto values excluded; the correlation between per capita outflow calls sending population and the

log of distance increased to –0.459 (significant at 0.01 level). Whether this means that friction of distance lessens because the longer Toronto distances from one end of the study area are excluded, or whether the closer relationship indicates that Toronto per capita outflows distorted the matrix, is uncertain. The b value (distance exponent) of –0.91 indicates unity values can be used for the distance exponent when Toronto is excluded.

Gravity Model Residuals From Regression

The assumption here is that residuals from regression, based on the gravity model, can be used to test the hypothesis that telephone interactions between pairs of places located along the Toronto-Stratford and Hamilton-London corridors would have a higher intensity of interaction than would pairs of places across corridors. Operationally, testing the hypothesis means that the regression model will underpredict for interactions between pairs of places along the corridors and will overpredict for interactions between pairs of places across the corridors. The values of the residuals are presented on Table 36. Positive values indicate underprediction and negative values indicate overprediction.

Before the results on Table 36 are analyzed, brief comments are made on the magnitude or actual number of calls since the data are not directly made available here. The distribution of calls is skewed with five pairs, (Toronto to Brantford, Hamilton, Kitchener, and Brantford and Hamilton to Toronto) having over 50,000 outgoing calls for the 10 day sample period, five pairs having 20,000 to 50,000 outgoing calls (London and Kitchener to Toronto, Kitchener and Guelph to each other, and St. Thomas to London), and 12 pairs having between 10,000 and 20,000 calls. At the other end of the distribution are 51 pairs having fewer than 1,000 calls between each other. Thus, only 59 pairs are in the 1,000 to 10,000 range with the mean being 7,260.

Table 36 provides some, though no means conclusive, evidence for the hypothesis that interactions along the corridors are greater than expected, given the population-distance relationships. For the Toronto-Stratford corridor only 22 of the 30 interacting pairs are underpredicted. This result would strongly support the hypothesis, except for the fact that 10 of the 22 underpredicted pairs are all the Toronto interactions. Similar underpredictions for Toronto interactions outside its designated Toronto-Stratford corridor also occur. Thus, without the Toronto interactions, only 12 of the 20 pairs are underpredicted. One conclusion is that Toronto interactions need to be handled separately because of Toronto's blanketing influence over the rest of the urban places in southern Ontario.

The results for the Hamilton to London corridor also provide limited support for the stated hypothesis. Only 14 of the 30 interacting pairs are underpredicted, a result not really supporting the hypothesis. However, 10 of the overpredicted pairs are all the Hamilton interactions. If these are removed, then 14 of the 20 remaining interacting pairs are underpredicted. Hamilton, then is the second problem in the analysis. First, its level of interaction is consistently low, both within its designated corridor and outside. Possibly, this low level of interaction is related to the importance of manufacturing in its economic structure, and the relative lack of dependence of

TABLE 36

LONG DISTANCE TELEPHONE FLOWS GRAVITY MODEL RESIDUALS FROM REGRESSION

TORONTO-STRATFORD CORRIDOR[a]

To	Toronto	Kitchener	Guelph	Stratford	Brampton	Orangeville
Toronto		0.510	0.055	–0.291	0.268	0.385
Kitchener	0.400		–0.109	0.203	0.056	0.384
Guelph	0.144	–0.094		–0.284	0.098	0.570
Stratford	0.380	0.232	–0.320		–0.106	–0.057
Brampton	0.247	–0.011	0.132	–0.180		0.541
Orangeville	0.462	0.176	0.626	0.096	0.502	

HAMILTON-LONDON CORRIDOR

To	Hamilton	London	Brantford	St. Thomas	Woodstock	Tillsonburg
Hamilton		–0.466	–0.327	–0.116	–0.435	–0.238
London	–0.081		–0.238	–0.016	1.761	0.163
Brantford	–0.248	–0.527		–0.228	–0.015	0.415
St. Thomas	–0.088	0.135	–0.188		0.075	0.460
Woodstock	–0.050	0.428	0.236	0.340		0.788
Tillsonburg	–0.081	0.371	0.438	0.529	0.593	

ACROSS CORRIDORS

To	Hamilton	London	Brantford	St. Thomas	Woodstock	Tillsonburg
Toronto	0.153	0.134	0.040	0.355	0.124	0.167
Kitchener	–0.224	0.121	0.290	–0.178	–0.094	–0.134
Guelph	–0.480	–0.170	–0.673	–0.277	–0.511	–0.845
Stratford	–0.312	0.275	–0.429	–0.226	0.047	–0.405
Brampton	– 0.023	–0.353	–0.373	–0.119	–0.261	–0.115
Orangeville	–0.257	0.069	–0.362	–0.354	–0.073	0.118

To	Toronto	Kitchener	Guelph	Stratford	Brampton	Orangeville
Hamilton	0.143	–0.151	–0.547	–0.320	–0.391	–0.323
London	0.595	0.074	–0.245	0.166	–0.485	–0.004
Brantford	0.129	–0.144	–0.682	–0.409	–0.355	–0.514
St. Thomas	0.508	–0.143	–0.262	–0.187	0.042	–0.267
Woodstock	0.567	0.211	–0.197	0.265	0.072	0.125
Tillsonburg	0.784	–0.020	–0.270	–0.265	0.001	–0.553

[a] Data comments are the same as for Table 35. A positive residual means underprediction and a negative value means overprediction.

Hamilton upon an external area. Also, Hamilton (and calls here include Burlington) is really at the merging point of both corridors.

The best evidence for the corridor hypothesis comes from the interactions across corridors. Of the 72 possible interactions, 47 or 65 per cent are overpredicted by the gravity model, and, if the 12 underpredicted Toronto interactions are removed, then the result is 47 of 60 or 78 per cent overpredicted pairs.

Further work is required to clarify the meaning of these message flows. First, complete data analysis for different size levels in the urban hierarchy appears in order; Toronto interactions, other cities over 50,000, cities 10,000 to 50,000 and towns should be tested separately. Second, separate regression analyses for the Toronto-Stratford, Hamilton-London, and across Corridor flows are suggested. Clearly, more research is required to understand what the variations in telephone message flow really mean.

Mail Flows

A second measure of the flow of messages is that of mail flows. To my knowledge, such data have not been previously used by geographers or other researchers interested in spatial interactions. This kind of flow data should complement telephone call data as a measure of socio-economic interaction between places.

The data available and usable are limited. With the co-operation of district postmasters in London and Toronto, letter outflow was obtained for most, but not all, of the town and city post offices in the Toronto-Stratford study area. The availability of the data depends on whether or not a sample count has been made on the destination of letters from the given post office. The letter outflows consists of long (business size) and short letters for a typical month suggested by the post office people. Data used here are for the period August 28 to September 24, 1966. No data are available on place of origin for inflow mail.

One particular problem with the outflows, even where the sample counts are made, exists. When the sample counts are made, a conversion figure is calculated. Using this conversion figure, the per cent of the outflow going to given places can then be calculated. However, the minimum cut-off point is different from post office to post office. And, of course, two per cent of one post office's outflow in absolute numbers will be greatly different from that of another post office operating at a different level of magnitude.

A further problem occurs with Metro Toronto data. The Metro area in 1966 was divided into a Toronto post office and eleven perimeter or suburban post offices. Because of the problem noted above, no complete total for Metro inflows from other places is available, since few centres send mail at the required level to all the perimeter post offices. Similarly, the reverse problem results for outflows from Toronto and the perimeter post offices. Even use of the Toronto city data poses problems because the Toronto city postal area differs from that of the incorporated city. Hence, for a gravity model application to Toronto, a population estimate must be made of the Metro area included under the Toronto post office.

Letter Flows and the Urban Hierarchy

Because of the incomplete data, no gravity model application is made. Also, no prior analysis exists, as existed for telephone flows, to compare the effect of missing data. Instead, letter flows have been analysed in relation to intensity of messages and flows up and down the urban hierarchy. This analysis is done using available data for cities (places with more than 10,000 population) for the combined Toronto-Stratford and Hamilton-London corridors. No data are available on outflows of letters for Brampton, Georgetown, Woodstock and Dundas.

As for the telephone calls, the mean for interacting pairs of cities is compared for flows along the Toronto-Stratford corridor and for flows across the corridor. The dominating effects of Metro Toronto again show up. Data have been calculated for both letter flows per 1,000 sending and per 1,000 receiving population. For the flows per 1,000 sending population (Table 37) the means are slightly higher for flows along the corridor than across it when Metro Toronto interactions are included but are slightly lower along the corridor than across it when Metro Toronto interactions are excluded. Hence, no evidence exists supporting the hypothesis of greater intensities of interaction along the corridor for the sending population when distance-population mass effects are ignored. For the letters received per 1,000 receiving population (Table 38), the means are higher in all cases for across corridor interactions. In part, these results occur because Hamilton and London are next to Toronto in the urban hierarchy and thus the urban hierarchy is clearly dominant, given these limited data.

Cities are arranged by population size on Tables 37, 38, 39. The tables respectively contain the letter outflow calculated on the basis of per 1,000 sending and receiving population and ratios between inflow and outflow for both indices. Thus, for instance, Kitchener-Waterloo sends 310 letters for each 1,000 of its population to Guelph. Guelph in turn sends 420 letters for each 1,000 of its population to Kitchener-Waterloo. The resultant ratio (Table 39) is that on the basis of sending population, Kitchener-Waterloo receives 14 letters from Guelph to every 10 it sends to Guelph, representing a measure of flow up the urban hierarchy. On the basis of receiving population, Kitchener-Waterloo receives 180 letters for each 1,000 of its population from Guelph; Guelph, however, receives 720 letters for each 1,000 of its population from Kitchener-Waterloo. The resultant ratio (Table 39) is 4.0. Hence, on the basis of receiving population, Kitchener-Waterloo sends four letters to Guelph for every one it receives from Guelph, representing a measure of the flow down the urban hierarchy.

It is hypothesized conceptually that organizational control in the urban system occurs through messages flowing up and down the urban hierarchy. This notion is implicit in the concept of an urban hierarchy, either as derived from the rank-size rule or from central place theory. Table 39 provides supporting evidence for this hypothesis. Note that since both sending and receiving population indices are calculated the distance decay factor is largely eliminated. Telephone flow data now need to be analyzed in a similar way to further test this notion of message "control" through the urban hierarchy.

TABLE 37

LETTER FLOWS PER 1,000 SENDING POPULATION, 1966

TORONTO-STRATFORD CORRIDOR

To	Metro Toronto	Kitchener	Burlington	Oakville	Guelph	Galt	Stratford	Preston
Metro Toronto		220	100	110	110	50	50	180
Kitchener[a]	2,260		70[b]	60	310	270	130	n.d.
Burlington	1,200	50		80	30	20	10	n.d.
Oakville	1,040	60	50		30	30	n.d.	40
Guelph	1,730	420	80	n.d.[c]		100	40	430
Galt	2,000	930	50	60	170		n.d.	50
Stratford	2,030	520	60	80	150	90		
Preston	1,830	850	40	n.d.	100	880	50	

Mean: 390 including Metro Toronto interactions; 200 excluding Metro Toronto interactions.

WITH HAMILTON-LONDON CORRIDOR

To	Metro Toronto	Kitchener	Burlington	Oakville	Guelph	Galt	Stratford	Preston
Hamilton	2,340	260	970	130	120	90	50	30
London	2,770	370	140	n.d.	140	120	260	n.d.
Brantford	1,420	150	30	20	60	30	30	20

To	Hamilton	London	Brantford
Metro Toronto	520	390	120
Kitchener	400	450	160
Burlington	1,510	100	50
Oakville	270	90	50
Guelph	570	240	120
Galt	530	330	200
Stratford	240	690	140
Preston	290	480	100
Hamilton		270	210
London	630		190
Brantford	370	210	

Mean: (London-Brantford-Hamilton interactions with each other excluded): including Metro Toronto interactions 380; excluding Metro Toronto interactions 250.

[a] Kitchener includes Waterloo.

[b] Data are rounded off to nearest ten because greater accuracy is not considered valid given the possible inconsistencies in the sample base of the data. Data are for the month of September and were provided by the London and Toronto District Post Offices.

[c] n.d. means no data available.

TABLE 38

LETTER FLOWS PER 1,000 RECEIVING POPULATION, 1966

TORONTO-STRATFORD CORRIDOR[a]

To	Metro Toronto	Kitchener	Burlington	Oakville	Guelph	Galt	Stratford	Preston
Metro Toronto		3,210	2,850	3,550	4,050	2,880	3,910	n.d.
Kitchener	150		120	110	720	990	700	1,720
Burlington	40	30		90	40	50	30	n.d.
Oakville	30	30	40		30	50	n.d.	n.d.
Guelph	50	180	60	n.d.		150	100	170
Galt	40	230	20	30	110		n.d.	1,110
Stratford	30	100	20	30	70	70		80
Preston	10	90	10	n.d.	30	350	30	

Mean: 510 including Metro Toronto interactions; 220 excluding Metro Toronto interactions.

WITH HAMILTON-LONDON CORRIDOR

To	Metro Toronto	Kitchener	Burlington	Oakville	Guelph	Galt	Stratford	Preston
Hamilton	380	640	4,430	730	710	810	600	680
London	290	590	410	n.d.	530	690	2,160	n.d.
Brantford	50	80	30	20	70	60	80	70

To	Hamilton	London	Brantford
Metro Toronto	3,180	3,700	3,710
Kitchener	170	280	340
Burlington	330	30	50
Oakville	50	30	50
Guelph	100	60	100
Galt	60	50	110
Stratford	20	80	50
Preston	10	20	20
Hamilton		410	1,670
London	410		610
Brantford	70	60	

Mean: (London-Brantford-Hamilton interactions with each other excluded): including Metro Toronto interactions 580; excluding Metro Toronto interactions 390.

[a] Data comments are the same as for Table 37.

TABLE 39

LETTER FLOWS: RATIOS IN FLOW TO OUTFLOW, 1966

PER 1,000 SENDING POPULATION

	Metro Toronto	Hamilton	London	Kitchener	Burlington	Brantford	Oakville	Guelph	Galt	Stratford	Preston
Metro Toronto		4.5	7.1	10.3	12.0	11.8	9.5	5.6	40.0	40.6	n.d.
Hamilton	0.2		2.3	1.5	1.6	1.8	2.1	4.8	5.6	4.8	9.7
London	0.1	0.4		1.2	1.4	5.3	n.d.	1.7	3.7	13.8	16.0
Kitchener	0.1	0.6	0.8		0.7	1.1	1.0	1.4	3.4	4.0	4.7
Burlington	0.8	0.6	0.7	1.4		3.0	1.6	2.7	2.5	6.0	n.d.
Brantford	0.1	0.6	0.9	0.9	0.3		2.5	2.0	6.7	4.7	5.0
Oakville	0.1	0.5	n.d.	1.0	0.6	0.4		n.d.	2.0	n.d.	n.d.
Guelph	0.1	0.2	0.6	0.7	0.4	0.5	n.d.		1.7	3.8	2.5
Galt	0.0[a]	0.2	0.4	0.3	0.4	0.2	0.5	0.6		n.d.	2.0
Stratford	0.0	0.2	0.4	0.2	0.2	0.2	n.d.	0.3	n.d.		1.0
Preston	n.d.	0.1	n.d.	0.2	n.d.	0.2	n.d.	0.4	0.5	1.0	

PER 1,000 RECEIVING POPULATION

	Metro Toronto	Hamilton	London	Kitchener	Burlington	Brantford	Oakville	Guelph	Galt	Stratford	Preston
Metro Toronto		8.4	12.8	28.1	71.3	74.2	118.3	81.0	72.0	130.3	n.d.
Hamilton	0.1		1.0	3.8	13.4	23.9	14.6	7.1	13.5	30.0	68.0
London	0.1	1.0		3.5	13.7	10.2	n.d.	8.8	13.8	27.0	n.d.
Kitchener	0.0	0.3	0.3		4.0	4.3	3.7	4.0	4.3	7.0	19.1
Burlington	0.0	0.1	0.1	0.3		0.6	2.3	0.7	2.5	1.5	n.d.
Brantford	0.0	0.0	0.1	0.2	1.7		2.5	1.4	1.8	1.6	3.5
Oakville	0.0	0.1	n.d.	0.3	0.4	0.4		n.d.	1.7	n.d.	n.d.
Guelph	0.0	0.1	0.1	0.2	1.5	0.7	n.d.		1.4	1.4	5.7
Galt	0.0	0.1	0.1	0.2	0.4	0.5	0.6	0.7		n.d.	3.2
Stratford	0.0	0.0	0.0	0.1	0.7	0.6	n.d.	0.7	n.d.		2.7
Preston	n.d.	0.0	n.d.	0.1	n.d.	0.3	n.d.	0.2	0.3	0.4	

[a] 0.0 indicates a value of less than 0.05.

The magnitude of the flow of messages via letters can be seen from Tables 37 and 38. Especially noticeable is the different magnitude of flow between Toronto and the other cities. The values for Toronto are all over 1,000 and indicate that the other cities sent from 1.4 to 2.7 letters per person to Toronto for the sample month. In turn they received from 2.8 to 4.0 letters per person from Metro Toronto. Recall again that these measures somewhat under-represent Toronto because letter flows to Toronto perimeter post offices are incomplete. As expected, cities close to each other have a high level of mail interaction—for instance Preston and Galt.

Using the results from Table 39, values greater than unity should indicate "control" of one city by another. In the upper diagonal, as values increase from left to right, the relative degree of "control" should increase. Because of missing data, the Table leaves some questions dangling. Burlington particularly shows inconsistent results.

For the cities used, Metro Toronto is completely dominant. A second level consists of Hamilton and London, with Kitchener-Waterloo somewhat weaker. These results support those reported by Carol in his analysis of functional city regions for southern Ontario (Carol, 1966). Burlington, Brantford, Oakville, Guelph and Galt are within the same level followed by Preston and Stratford at the lowest level. A number of variations within the ratios, such as the inconsistent values of Brantford and Burlington, pose questions. Nor is the question of differences in type of city and the effect on letter flows considered. Nevertheless, this use of flows data to provide a measure of the "control" via the urban hierarchy appears to merit further development.

Newspaper Flows

Daily newspaper circulation has been used by researchers in the past to outline areas of city influence and as a complementary indicator of levels in the urban hierarchy. Goheen has used such data in analyzing the external relations of the central places of southern Ontario (Goheen, 1964). Whitfield, in a general study of newspaper influence in the Toronto area, suggested that Toronto's domain was shrinking (Whitfield, 1966). And, in my study of the Hamilton-London corridor area, I compared interactional areas of daily newspapers for 1941 and 1961 for Hamilton, Brantford, Woodstock and London (Russwurm, 1964).

The results of the 1941 and 1961 comparison in the Hamilton-London corridor area showed considerable stability in the interactional areas over time. The only change was a shrinking of Woodstock's newspaper interactional area, mostly to London, a city which had a faster population growth rate 1941 to 1961. Also, Woodstock's interactional area was overlapped to the north and south as expected. The hypothesis was stated and supported that along a corridor, interactional areas would be elliptical and would be approximately the same distance in diameter along the corridor regardless of city size.

Here, newspaper circulations are treated as a third type of message, through which higher order urban centres organize their surrounding area and lower order urban nodes. Newspaper flows can also be used to provide a ranking of places in the urban hierarchy using reasoning akin to that used for mail flows. Newspapers provide

information on day to day events, political, social, and economic, help structure the retail and wholesale zone of influence, help create radio and television zones of influence. Clearly, they are a major source of messages influencing people, both in the organization of the internal and the external spatial structure.

Basic data on the daily newspapers serving both the Toronto-Stratford and the Hamilton-London corridors are given on Table 40. The last two columns are indicators of flows up and down the urban hierarchy. The permeating dominance of Metro Toronto is again evident in that over 900 papers are sent out for each one received from outside. For newspaper interactions, the organizing flow channel is down the urban hierarchy. There are no "requesting" messages for goods, services and contacts up the hierarchy, as exist for telephone and mail messages.

A few spatial implications are worth noting. The wider net of influence cast over a larger land space by London and Kitchener-Waterloo is seen in their higher ratios of outflow to inflow. Cities having a ratio of less than one are on the receiving end of newspaper messages, even for their own population. Also, the cities with a greater number of persons per newspaper distributed internally are lowest on the urban hierarchy—for example Oakville and Brampton, neither of which completely dominate any external land space of their own (see Figure 24).

Two spatial units of newspaper circulation, however, have to be considered. A city newspaper may dominate its internal area and control a relatively small spatial area externally, as does Hamilton, or it may control a large external area as well as its own internal area, as do Toronto, London and Kitchener-Waterloo.

Another influential factor in determining interactional areas is that of city type. Hamilton is an industrial city with over 50 per cent of its employed population engaged in manufacturing. Hence, its dependence is less pronounced on its surrounding area than cities like London, Stratford or Woodstock. The per cent of newspaper circulation outside the city provides a crude measure of the regional influence of the city. A reasonably safe assumption states that the greater the per cent of newspaper circulation outside the city, the greater is the regional influence of the city. The regional importance of London is seen in its having 59 per cent of its circulation outside the city. London has increased the per cent of its circulation outside from 55 to 59 per cent since 1941. One result of a high per cent of circulation outside the publishing city is that a large land space receives its messages from such a city. The fact that Burlington does not yet possess its own daily paper is a strong indication of its dominance by Hamilton and, to a lesser degree, by Metro Toronto. The three Toronto dailies send one paper to Burlington for every four inhabitants.

The above discussion has assumed: (1) equal receptiveness on the part of any person to receive a newspaper message; (2) equal entrepreneural ability on the part of the persons publishing each paper.

Figure 24 outlines the interactional areas of the daily newspapers penetrating the Toronto-Stratford corridor area. It was derived from the Audit Bureau of Circulation data, which provided a list of all places receiving 25 or more newspapers daily. Instead of outlining only zones where the majority of messages are received from one city

TABLE 40

DAILY NEWSPAPER FLOWS, 1966

	Population 1966	Circulation[a] Total	Within Publishing City	Outside Publishing City	Per Cent Circulation Outside	Persons Per Paper Circulated Within City	Ratio Internal Circulation to Outside Papers Received	Ratio Outflow to Inflow
The three Toronto Dailies	1,824,481	815,884	507,119	308,765	38	3.6	797.3	915.4
Hamilton Spectator	385,000[b]	119,704	95,747	23,957	21	4.0	4.5	6.3
London Free Press	194,416[b]	122,727	50,413	72,314	59	3.8	8.9	9.9
Kitchener-Waterloo Record	125,255[b]	45,490	31,410	14,080	31	4.0	5.2	9.2
Brantford Expositor	59,854	24,084	16,569	7,515	31	3.6	3.6	1.6
Guelph Mercury	51,377	16,113	11,428	4,685	29	4.5	2.2	2.4
Oakville Journal Record	48,000[b]	7,016	6,172	844	12	7.7	0.5	0.6
Galt Reporter	46,871[b]	13,267	10,410	2,857	22	4.5	2.3	3.7
Brampton Times and Conservator	36,264	7,048	5,255	1,793	26	6.8	0.7	0.8
Woodstock Sentinal Review	24,027	10,081	6,213	3,868	39	3.9	1.5	0.9
Stratford Beacon-Herald	23,068	10,026	5,661	4,365	44	4.1	2.3	1.8

[a] Data source is the Audit Bureau of Circulation; circulations are based on the first 6 months of 1966 but refer to daily totals.

[b] The Hamilton population includes Dundas and Burlington with 61,000 estimated as the population for Burlington. The London population is the metropolitan area population; the Kitchener-Waterloo population includes Kitchener, Waterloo and Bridgeport; the Oakville population is an estimate for the built-up area; the Galt population includes Preston.

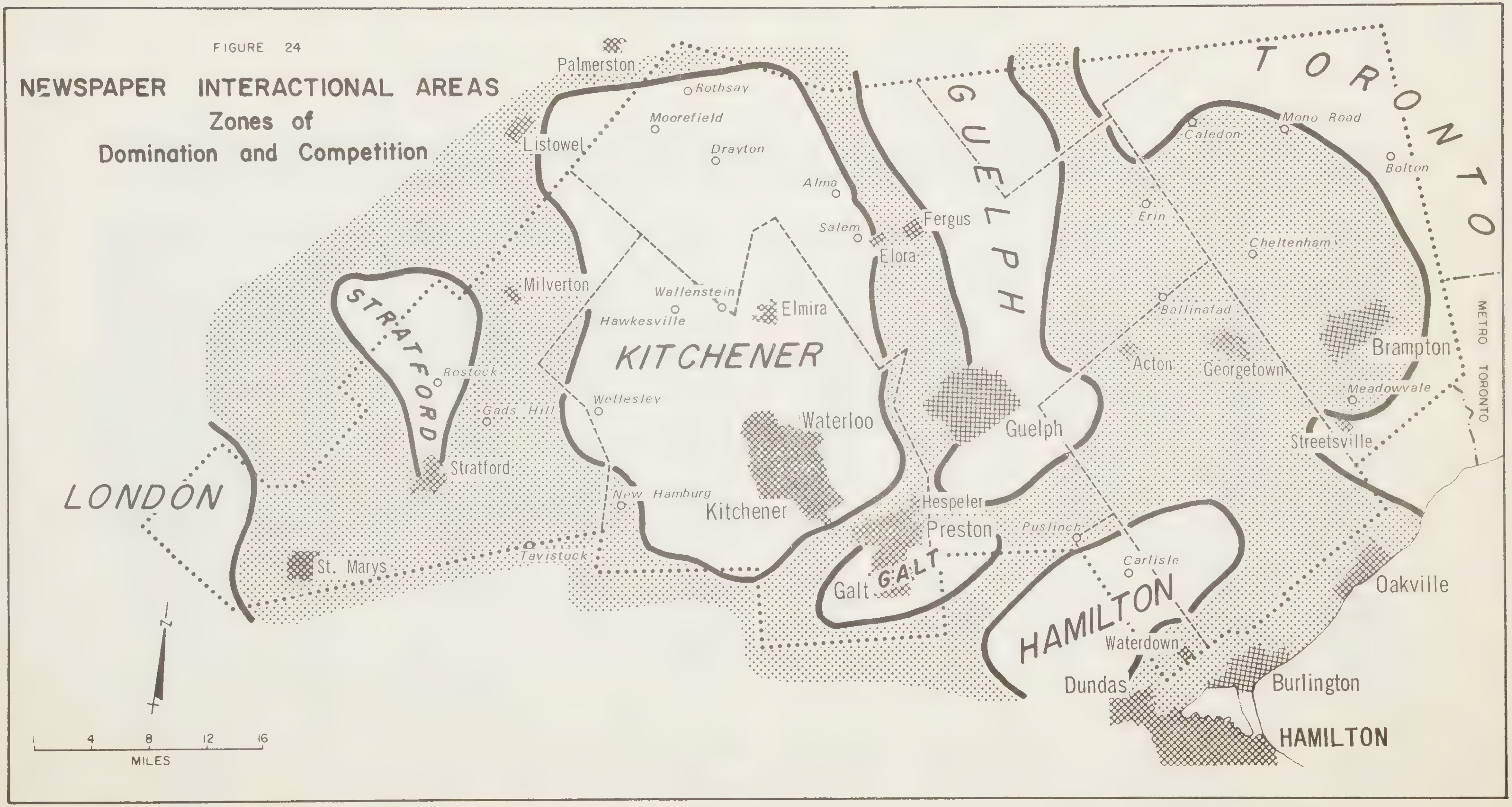


FIGURE 24

NEWSPAPER INTERACTIONAL AREAS
Zones of
Domination and Competition

newspaper, the map shows zones completely dominated by one city newspaper, i.e., no place within that zone receives 25 newspapers from any other newspaper. As well, the zones of competition between city newspapers is shown. It is in these zones that the receivers of the printed message have a choice of newspapers.

Two spatial effects of the interactional areas reflecting a corridor effect stand out. One is the elliptical zones of dominance; the other is the truncated southern limits of most of the zones of dominance. This latter spatial effect results from competition with the Hamilton-London urban corridor. Galt's newspaper interactional area is affected both by the corridor to the south and by the urban hierarchy impact of Kitchener-Waterloo and Guelph. Kitchener and Stratford are affected by the competition with London.

The operational effects of highways along which newspapers are delivered can be traced. The very narrow zone of competition between Guelph and Kitchener-Waterloo straddles Highway 6. The competition map also showed competition between London and Stratford along Highway 23 and Kitchener-Waterloo and London along Highway 9. And the flow of Toronto messages west along the lake front corridor into Oakville and Burlington is also evident.

The dominance of Toronto in the eastern part of the study area is everpresent. Neither Brampton nor Oakville newspapers have yet established a zone of dominance. In fact, Oakville does not send a majority of newspaper messages to any area, including that of its own populace.

This dominance of Toronto over the eastern part of the study area can be conceptualized as a wave along a surface whereby the message impact of Metro Toronto is diffused. In this area, the message surface with all its nodes is completely, or mainly, dominated by Metro Toronto. As the distance decay effect sets in, the flows of messages from Toronto become concentrated along distinct paths (the highways) focussing on the larger urban nodes. A similar pattern can be identified on maps of wholesaling (commodity) flows for a Georgian Bay Region study (Thoman and Yeates, 1966).These nodal flows from Toronto extend north-west beyond the study area to Palmerston and Listowel and, in the corridor study area, reach the westernmost city and town of Stratford and St. Marys.

A preliminary map showing this type of diffusion effect is partially completed and will be expanded to include all of the Hamilton-London corridor area. The most noticeable spatial effect seen on this partially completed map is the noticeable weakening of these nodal flow intrusions of Toronto and London in the Kitchener-Waterloo interactional area.

Like a pioneer settlement frontier area, message flows of newspapers exhibit, then, a continuous surface followed by a discontinuous pattern of nodes. Presumably, the surrounding land space will be filled in from these outlying nodes, should the sending city intensify its organizational impact on the land space.

Three types of message flows, telephone, mail and newspapers have been briefly investigated for the Toronto-Stratford area. Generally these types of flows have

identified a corridor effect in association with the urban hierarchy effect. Such flows, along with flows of people for various purposes and flows of commodities, are major factors—even dominant factors—that must be considered in regional planning and regional government reorganization. In the final part of this report some suggestions on the application of the urban systems framework for regional planning and regional government are made.

PART VIII

A CORRIDOR URBAN SYSTEM LOCATIONAL MODEL

An ideal model of an urban system would demand combining both the interactional and the locational sub-systems. Moreover, in the spatial approach to urban systems used here, such an ideal model would also have to combine the areal units of the land space matrix, a surface, with the nodal units of villages, towns and cities. Where data on flows are available, present methodology permits combining the interactional and locational sub-systems by using Berry's field theory (Berry, 1968A, 1968B), which depends upon the multivariate statistical technique of canonical correlation. Through this technique, n variables can be compared with each other, unlike multiple regression, where the measured effect is unidirectional. The problem of putting together the areal units of nodes and segments of a surface are not yet resolved, unless the segments of the surface are assigned to the nodes.

Attempts to obtain flow data for the different level of nodes used in this study were limited in their success. Hence, no attempt is made to develop a model which would combine interactional and locational elements either for the nodes or the segments of the surface, i.e., the township blocks of the land space matrix. What seemed most feasible, given the data at hand, was the possibility of locational models for selected elements of the land space surface using multiple regression techniques. Cross-sectional comparisons using the same variables for 1941 and 1966 will have some predictive powers, especially since the factor analysis results for the land space matrix suggested reasonable stability between 1941 and 1966.

Variables for the Locational Model

Five variables loading highly and consistently on the *Urban Fringe* and *Urban Shadow* factors for 1941 and 1966 were used as both independent and dependent variables. These variables were: (1) the per cent population non-farm; (2) the per cent of non-farm owned non-resident land; (3) the per cent non-farm owned vacant land; (4) the per cent non-farm owned residential land; (5) the per cent non-farm landholding land.

Four other variables are used only as independent variables. Two are from the assessment roll data set, namely per cent total non-farm owned land and per cent non-farm assessment is of total assessment. Both these variables are summation measures of urbanization impact and are thus used as measures of the total magnitude of urbanization. To these independent variables are added two spatial variables: (1) distance to boundary of the nearest city; and (2) distance to the nearest corridor highway (Highway 7, 5, or 401). These two spatial variables are considered measures of the decline of urban influences outward from cities and away from the corridor highways. While not contributing as significantly to the factor analysis output as postulated that they would, the possibility remained that they might contribute to a multiple regression model.

Each of the first five variables was, in turn, treated as a dependent variable. This approach was used because interdependencies exist, but also because each variable is a useful indicator of the spread of urbanization across the land space matrix. Again, the stepwise multiple regression BMD program is used so that the added contribution of each variable could be easily seen.

The Multiple Regression Models

Comments on data and results presented on Table 41 follow. The spatial units used were the township blocks delimited for the land space matrix analysis; 334 blocks were available in 1966 and 308 blocks were available in 1941. All ten of the multiple regression models are significant at the 0.001 probability level using an F test. No transformations of data were used; since standard deviations were greater than means for some variables, transformations might have increased the power of the models. Nor are the residuals from regression mapped and analysed, though preliminary inspection of the residuals suggests such mapping would help increase understanding and would suggest possible improvements for some of the models. Only those independent variables are included which increased the coefficient of determination R^2 by 1 per cent or more. Variables in the equations are presented in order of entrance with the multiple correlation coefficients also being given in the same order.

Summary results are presented on the Table 41 from which the following conclusions are emphasized. (1) A high level of predictability occurs with explanation being over 80 per cent for 5 of the 10 models and still over 55 per cent for the most poorly "explained" variable, residential land in 1966. (2) The multiple correlation coefficients have increased, with one exception, from 1941 to 1966. Such increases suggest that the spatial variations of the urbanization measures are becoming more regular and more predictable. (3) The similarity of variables entering into the equations in both 1941 and 1966 is noted; all but two of the variables used in the equations for 1966 were included in the 1941 equations. As noted in the analysis of the land space matrix, the relationship of urbanization expansion elements, though barely incipient in 1941, were similar to the 1966 relationships, suggesting considerable stability in the impact of expanding urbanization for the five variables used as dependent variables. (4) The increasing strength of the spatial variables by 1966 is shown by the generally higher correlations (see correlation matrix Table 42), especially for the variable distance to corridor highway. Each of the dependent variables tested is analyzed, in turn, below, with the most powerful models presented first.

The satisfactory level of prediction was anticipated for the multiple regression models for 1966 but not for 1941 because the analyses in other parts of this report had indicated more irregularity in the urbanization variables in 1941. Such irregularity, while reflected in the generally higher standard deviations for 1941, as compared with 1966, affected the multiple regression relatively little.

Of the dependent variables tested, the explanation of X5, landholding is highest in both years at 92.4 and 92 per cent for 1966 and 1941, respectively. However, in 1941, in addition to the three variables of total non-farm owned land, non-resident land and non-farm assessment, it took two additional variables, non-farm population and vacant

TABLE 41

MULTIPLE REGRESSION CORRIDOR URBAN SYSTEM LOCATIONAL MODELS

	1941[b] Means	1941[b] Standard Deviations	1966[b] Means	1966[b] Standard Deviations
Variables Both Dependent and Independent:				
X_1 Per cent population non-farm	11.2	12.4	39.9	27.5
X_2 Per cent non-farm owned non-resident land	3.0	5.0	12.1	14.4
X_3 Per cent non-farm owned vacant land	1.5	3.2	5.9	7.4
X_4 Per cent non-farm owned residential land	0.3	0.5	1.3	1.8
X_5 Per cent non-farm landholding land	3.8	5.7	16.4	17.4
Variables Independent Only:				
X_6 Per cent total non-farm owned land	4.6	6.7	21.7	21.7
X_7 Per cent non-farm assessment of total assessment	4.3	7.9	26.6	22.2
X_8 Distance (miles) to boundary of nearest city	8.7	0.4	8.7[c]	0.4
X_9 Distance (miles) to nearest corridor highway (highways 7, 5, or 401)	8.5	6.7	8.0[d]	6.8

Regression Models[a]:

X_1 Per Cent Population Non-Farm

1966

X_1 = 16.21 + 0.76X7 + 0.55X5 – 0.69X9
R = X7 0.895, X5 0.933, X9 0.946
R^2 = 0.894

1941

X_1 = 6.28 + 10.42X4 + 0.72X7 + 1.11X5 –0.80X6 – 0.21X9
R = X4 0.745, X7 0.796, X5 0.809, X6 0.818, X9 0.826
R^2 = 0.681

X_2 Per Cent Non-Farm Owned Non-Resident Land

1966

X_2 = 50.22 + 0.47X5 = 0.57X3 – 5.63X8
R = X5 0.895, X3 0.914, X8 0.926
R^2 = 0.858

1941

X_2 = 0.03 + 0.72X6 + 0.61X3 – 0.32X5 – 1.20X4
R = X6 0.854, X3 0.888, X5 0.898, X4 0.906
R^2 = 0.821

X_3 Per Cent Non-Farm Owned Vacant Land

1966

X_3 = 1.11 + 0.27X2 + 0.20X5 – 0.05X1
R = X2 0.839, X5 0.852, X1 0.860
R^2 = 0.739

1941

X_3 = 0.01 + 0.45X2 = 0.43X5 – 0.30X6
R = X2 0.749, X5 0.785, X6 0.812
R^2 = 0.660

X_4 Per Cent Non-Farm Owned Residential Land

1966

X_4 = X42 – 0.046 + 0.03X1 + 0.03X7
R = X1 0.727, X7 0.746
R^2 = 0.556

1941

X_4 = –0.01 + 0.03X1 + 0.02X7 – 0.02X2
R = X1 0.745, X7 0.764, X2 0.777
R^2 = 0.603

X_5 Per Cent Non-Farm Landholding Land

1966	1941
$X_5 = -1.41 + 0.51X6 + 0.24X2 - 0.28X7$	$X_5 = -0.13 + 0.93X6 - 0.24X7 + 0.07X1 + 0.38X3 - 0.26X2$
R = X6 0.932, X2 0.949, X7 0.961	R = X6 0.914, X7 0.938, X1 0.948, X3 0.954, X2 0.959
$R^2 = 0.924$	$R^2 = 0.920$

[a] All models are significant at the 0.001 probability level; n = 308 township blocks in 1941 and 334 township blocks in 1966. Data source is township assessment rolls.

[b] These parameters are based on the spatial units of township blocks.

[c] The same distances for 1941 and 1966 reflect the completely comparable boundaries used for both 1941 and 1966.

[d] The lesser distance in 1966 reflects the addition of Highway 401.

land to reach the 92 per cent level of explanation. While total non-farm land entered first in both years, the regression coefficient was higher in 1941 (0.93 to 0.51). As well, the variable non-resident land had a negative sign in 1941 but became positive by 1966. This shift in the sign of the regression coefficient, suggests that in 1941 non-resident land tended to be located away from landholding but by 1966 it occurred more in spatial proximity. From Table 42, giving the correlation matrix for 1941 and 1966, the increase from 0.26 to 0.66 in the simple correlation for these two variables is noted. The tentative explanation suggested is that non-resident owned land in 1941 occurred in scattered parcels, while landholding was more concentrated in the vicinity of the major cities. As for all but one of the other variables tested, the 1941 model needs more variables and is more difficult to interpret fully.

The second most powerful model for 1966 was for non-farm population with an R^2 of 0.89. For 1941 the R^2 value was only 0.68 and was exceeded by the R^2 value of 0.82 for the non-resident variable. Again all three variables in the 1966 model, landholding, non-farm assessment, and distance to nearest city occurred in the 1941 model, though the order of entry was different. Two additional variables were again included one of which, residential land, entered first into the equation with a very high regression coefficient (10.42). The spatial variable, distance to corridor highway, though last in the equation in each year, contributed more in 1966, 0.013, as compared with 0.008 in 1941, providing some evidence of increasing corridor effect. Again, the 1941 model is more difficult to explain; for instance, according to the multiple regression model, the per cent population non-farm increases as the proportion of total non-farm owned land decreases. Possibly the low proportion of non-farm owned land in 1941 (block mean 4.6 per cent) means that a few large parcels, not spatially proximate to non-farm population, could lead to this inverse relationship. However, since the simple correlation is positive (0.42), the opposite signs appear to be a result of the partial correlation calculations resulting from the mathematics of multiple regression (Blalock, 1960).

Per cent non-resident land was next in line in 1966 with 85.8 per cent of the variance explained—an increase from 82.1 per cent in 1941. Vacant land and landholding occurred in the equation in both years but landholding had a negative regression coefficient in 1941. Worthy of note also is the inclusion of the spatial variable distance to nearest city in1966. This variable has contributed much less to the models than was expected, though showing the expected inverse distance relationship. Possibly the effect of this distance variable is relatively limited in these multiple regression models because of the inclusion of township blocks outside the basic urban corridor noted on the maps prepared for the land space matrix analysis. Or contrariwise, the distances to cities are sufficiently similar for all blocks.

Entering first into the equation for the second model in 1941 is the variable total non-farm owned land. The undue influence of this variable in 1941 is seen in its occurrence in all but the vacant land model. In contrast it occurs only in the landholding model in 1966; as noted earlier, landholding accounts for over two-thirds of non-farm owned land and this strongly influences the variable non-farm owned land.

Ranking fourth in power of the multiple regression models for both 1941 and 1966 is the variable vacant land. This is the only variable having the same number of variables

TABLE 42

CORRELATION MATRIX OF THE URBAN SYSTEM LOCATIONAL VARIABLES

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1.00 1.00	0.26	0.24	0.74	0.38	0.42	0.67	−0.11	−0.28
X_2	0.66	1.00 1.00	0.75	0.09	0.77	0.85	0.42	−0.34	0.04
X_3	0.54	0.84	1.00 1.00	0.11	0.73	0.67	0.25	−0.23	−0.05
X_4	0.73	0.46	0.38	1.00 1.00	0.21	0.26	0.60	0.01	−0.25
X_5	0.75	0.90	0.82	0.53	1.00 1.00	0.91	0.36	−0.32	−0.02
X_6	0.78	0.87	0.77	0.57	0.93	1.00 1.00	0.58	−0.31	−0.03
X_7	0.90	0.56	0.43	0.72	0.61	0.73	1.00 1.00	−0.13	−0.14
X_8	−0.52	−0.60	−0.48	−0.35	−0.51	−0.52	−0.47	1.00 1.00	0.18
X_9	−0.48	−0.13	−0.05	−0.31	−0.18	−0.19	−0.40	−0.08	1.00 1.00

1966

1941

Variables

X_1 Per cent population non-farm

X_2 Per cent non-farm owned non-resident land

X_3 Per cent non-farm owned vacant land

X_4 Per cent non-farm owned residential land

X_5 Per cent non-farm landholding land

X_6 Per cent total non-farm owned land

X_7 Per cent non-farm assessment of total assessment

X_8 Distance (miles) to boundary of nearest city

X_9 Distance (miles) to nearest corridor highway (highways 7, 5, or 401)

in its explanatory equation in 1941 as in 1966. As well, the first two entering variables are the same in both years—non-resident land and landholding. In 1966 the variable non-farm population replaces total non-farm owned land both having negative regression coefficients in their respective equations.

Surprisingly low is the explanatory power of the multiple regression model for residential land. In 1966 only 56 per cent of the variance was explained—a lower per cent than in 1941, when 60 per cent was explained. Why this should be is unclear, especially since simple correlations of residential land are moderately high with all other variables used. One suggestion is that this prominent urban fringe variable is directly associated with non-farm population and non-farm assessment and that most other variables are intercorrelated in a similar way as residential land. If so, then little further explanation would result from any of the other independent variables used.

The multiple regression models are satisfactory urban system predictors for the locational elements tested but provided only limited evidence of a transportation corridor effect. Although the corridor effect measured by distance to nearest corridor highway proved significant only for the non-farm population element, the fact that simple correlations of this spatial variable with seven other variables increased 0.20 or more is suggestive of increasing influence by 1966.

It is also worth noting that simple regression models should perhaps replace multiple regression models more frequently if the desired level of prediction is not too restrictive. For instance, a correlation coefficient of 0.7 mathematically explains approximately half of the variance in a given association of variables. The first variable entering each of the ten multiple regression models presented here exceeded the value of 0.7. Hence, in every case a single variable could explain over half of the variance of the dependent variable. Of the variables used, the non-farm population and non-farm assessment variables are easiest to obtain and compile. From the table giving the correlation matrix it is noted that non-farm population is correlated at 0.7 or higher with residential land, landholding, total non-farm owned land and non-farm assessment. Judicious use of single variables, depending on the desired predictability, thus, could, at times, result in efficient results with much less effort.

PART IX

CORRIDOR URBAN SYSTEMS, REGIONAL DEVELOPMENT PLANNING AND REGIONAL GOVERNMENT

No attempt is made here to present a treatise on regional development planning or regional government and their relationship with urban systems. Rather, the following comments arise from the experience gained over the past two years in the course of the preparation of this report.

The process of the regional development plan is outlined as consisting of three phases: evaluation, development and implementation (Planning and Resources Institute, University of Waterloo, 1968). In other terms, what is being suggested is that a regional development study must identify existing development *trends,* the evaluation phase, and establish feasible *alternatives,* the development phase. Trends and alternatives then demand that critical *decisions* be made—the implementation phase—a passive decision in accepting trends or an active one in choosing deliberately between alternatives. At the apex of this process of the regional development plan, thus, stand the political decision makers. Similar reasoning is detectable in the Metropolitan Toronto and Region Transportation Study, *Choices for a Growing Region*, which stresses the need to consider alternatives.

Based on the foregoing discussion, two types of development plans are recognized. One is a trends plan, which is based on what has happened to the urban nodes and their surrounding land space; the other is the alternatives plan, which attempts to make improvements by changing some of the developing trends. Both these types of development plans are presented in the MTARTS study *Choices for a Growing Region.* A critical problem in projecting either type of plan into the future is the over dependence on population and economic growth projections. More study needs to be directed towards feasible development plans that meet peoples' needs and that can, by the same token, accommodate a wide range of intensities and magnitude of development. As the urban systems relationships become better understood such plans should become possible.

An example of a local government study which is basically a trends type plan is the *Peel-Halton Local Government Review* (Plunkett, 1966). Since Peel and Halton are part of the land space matrix of the Toronto-Stratford corridor, the following comments, based on my research findings, are made on the development pattern accepted by Plunkett. These comments are directed only at the assumptions made concerning the development pattern. Basically three threads of reasoning were followed in recommending that separate urban and rural counties be established for regional government for Peel-Halton. First, the projected populations suggested that the bulk of the people could be concentrated in the southern, more intensely urbanized part. Second, commuting flows to work, derived from a MTARTS study, were used to argue unconvincingly for increasing interdependence within the area. Third, the assumption is made that the differing population densities and resulting differences in level of services provided lead to an urban "South" and rural "North."

Each of these threads of reasoning depends on projecting existing trends and largely lack a conceptual framework based on existing theory of urban systems.

The recognition in the Peel-Halton study of the east-west transportation corridor and its effect in concentrating population is sound. However, when combined with the argument for increased interdependencies based on the commuting data, it would logically lead to a conurbation between Toronto and Hamilton. Nor is the argument that a high level of population concentration in the south and a lesser level of population concentration in the north a sufficient reason to accept an urban-rural dichotomy. The analysis of the land space matrix in the present study shows that the influence of expanding urbanization is especially noticeable in three of the rural townships noted by Plunkett, namely Albion, Caledon and Nassagaweya. The suggested municipal reorganization, then, implicitly assumes a developing corridor conurbation in the south—an acceptance of existing trends. At the same time, the recommendation for a separate rural northern county has tended to ignore existing trends, for example, the abandonment of farm land, the landholding and increasing residential use of the Niagara Escarpment, and the conservation and recreation developments occurring.

Using the evidence provided in the Peel-Halton study, combining it with evidence derived in the Toronto-Stratford corridor study, and placing both in an urban systems framework, a feasible alternative municipal reorganization is proposed. The primary urban systems concept that must be recognized when dealing with the land space matrix of the external spatial structure, is the concept of the urban hierarchy and the functional organization of the surrounding land space at different scales of areal extent and magnitude, depending on the level of the particular node in the urban hierarchy.

In the Peel-Halton area, the verified fact is the blanketing influence of Metro Toronto (see Parts III and VIII of this study) both in the locational and the interactional sub-systems. Hence, if the decision were reached at whatever political decision making level that a conurbation is to be avoided, then the municipal reorganization accepted must deliberately stress the development of separate nodes at a level in the urban hierarchy high enough to avoid complete domination by Metro Toronto. The feasibility of such a development is present in the existing trends. Combining Mississauga (Toronto township), Brampton-Bramalea, Oakville and Burlington into one regional unit, as suggested in the Peel-Halton study, will promote coalescence into a conurbation, not strong independent nodes.

The most feasible reorganization would support the deliberate further development of Oakville and Brampton-Bramalea as higher level centres in the urban hierarchy with a population of perhaps 300,000. As noted by Plunkett, a critical factor in the area is the lack of a central core city from which the surrounding land space and lesser nodes can be organized. Oakville and Brampton-Bramalea are such potential centres which can only reach the level in the urban hierarchy needed for relative independence from Toronto if regional planning strategies are deliberately attuned to promote such development. As noted in the analysis of newspaper flows, both centres are dominated internally and externally by Metro Toronto. However, as noted in the Peel-Halton study, both centres already provide employment for about two-thirds of their population giving a sound basis for further employment opportunities to be developed. To further reduce the trend towards conurbation development, considerable parts of

Mississauga should be made part of Metro Toronto. At the other end of the Peel-Halton urbanizing corridor, Burlington is clearly integrated into the Hamilton metropolitan area, as was noted in the present research and as is evident from material presented in the Peel-Halton study regardless of attempts made to reach contrary conclusions.

Flows between Burlington and Oakville are weak for two urban system reasons. First, Burlington is at a competing level in the urban hierarchy with Oakville; hence, flows out from these cities are not towards each other but up the hierarchy to a larger centre. Second, Burlington is dominated by Hamilton and Oakville by Toronto.

A local government review report is to be completed in 1969 for the Waterloo county area with some reference to the city of Guelph and its surrounding area. This Grand River Triangle of cities contains the highest level urban node in the Toronto-Stratford urban corridor, next to Metro Toronto. Here is an area with different spatial urban system characteristics from those of Peel-Halton. The area is dominated by Kitchener-Waterloo but much less so than is Peel-Halton by Toronto. The intensity of flows between Kitchener and the lower order centres of Galt, Preston and Guelph fit the urban hierarchy notions and are supported by evidence from the analysis of both the locational and the interactional sub-systems. Such flows are more dispersed in the Peel-Halton area. But again, based on recognition of the corridor effect, a conurbation can be expected if current trends are accepted for future development as apparently the Ontario Housing Corporation has assumed, with its projected satellite community between Kitchener and Guelph. If, for planning or political purposes, a conurbation is seen as a less desirable goal than some other form of development, then again growth of separate centres needs to be deliberately fostered.

One other problem arises in regional government and regional development studies. That is the excessive concern with what is really a mythical problem—delimiting boundaries. The myth occurs in the argument that accurate boundaries are very difficult or impossible to define. But development regions by the nature of the term imply that change is to occur. Hence, the problem really is one of identifying the growth poles and the levels in the urban hierarchy which will be used to divide the land space under study. As Figure 24 of newspaper flows, for example, shows, there are always zones of land space where competition between urban centres occurs, both from locational and from interactional standpoints: thus, the boundary problem is only one of finding that small zone where people do not have strong ties with one centre over another. This peripheral zone notion is further discussed for Iowa (Berry and Schwindt, 1968). The recent delimitation study of the Georgian Bay region (Thoman and Yeates, 1966) has outlined practical techniques for delimiting other boundaries with considerable detail and precision. Further research is presented in this study on ways of handling this so-called problem. It is discussed here because it has been a problem for the Peel-Halton area and has been overly magnified in a number of the briefs submitted in the Waterloo county local government study.

The suggested spatial pattern in this area would be the deliberate growth of the currently dominant centre, Kitchener-Waterloo as one of eight higher order development regions for the Western Ontario urban corridors. These centres would be Hamilton, London, Windsor, St. Catharines, Brantford, Kitchener-Waterloo, Oakville and Brampton. This suggested number of higher order development regions is an

increase in the number suggested by Carol in an earlier report (Carol, 1966). Also assumed here are alternative development plans to strengthen certain aspects of current trends in order to deliberately promote growth of certain of these centres.

The analysis of message flows has shown the strong position of Kitchener-Waterloo in an intermediate location between Toronto, London and Hamilton. For regional government purposes, regional sub-centres will probably have to be recognized in Galt, Preston and Guelph for this area. Stratford is clearly a regional sub-centre under London.

The spatial organization outlined above is based on recognizing the concentrating influence of an urban corridor system type of development superimposed on the radiating influence of a very dominant metropolitan centre. The argument made is that, in order to arrest the blanketing effect of Metro Toronto dominance and prevent a continuous conurbation from developing over time, a deliberate recognition of an urban system is needed. This group of eight centres would compete for population growth in Western Ontario's urbanizing corridor area at the same level and thus maintain relative independence from each other. At the same time, day to day high density interactions between such centres would be minimized because of their size. A minimum of 250,000 people would probably ensure independence. However, the group of cities would function as an integrated urban system providing special services and goods to each other. If some such overall development scheme, based on recognizing an urban systems approach with its key concept of urban hierarchies is not recognized, then the expectation is that the urban corridor trends in Western Ontario in conjunction with the metropolitan dominance of Toronto will lead to linear conurbations. The developing urban growth trends noted in this Toronto-Stratford corridor study point in that direction.

BIBLIOGRAPHY
REFERENCES USED

Allen, G., *An Analysis of the Commuter Pattern to a Major Industrial Node in Waterloo,* Unpublished B.A. Thesis, Waterloo, Ontario: Dept. of Geography, Waterloo Lutheran University, 1967.

Berry, B.J.L., *Essays on Commodity Flows and the Spatial Structure of the Indian Economy,* Research Paper 111, Chicago: Dept. of Geography, University of Chicago, 1968A.

Berry, B.J.L., "A Synthesis of Formal and Functional Regions using a General Field Theory of Spatial Behavior" in *Spatial Analysis,* eds. B.J.L. Berry and D.F. Marble. Englewood Cliffs, N.J.: Prentice-Hall, 1968B, 419-430.

Berry, B.J.L., *Theories of Urban Location,* Resource Paper No. 1, Washington: Commission on College Geography, Association of American Geographers, 1968C.

Berry, B.J.L., *Geography of Market Centres and Retail Distribution,* Englewood Cliffs: Prentice-Hall, 1967A.

Berry, B.J.L., "Policy Implications of an Urban Location Model for the Kanpur Region," Paper prepared for a Seminar on Urban and Industrial Development of the Kanpur Region, Kanpur, India, 1967.

Berry, B.J.L., "Internal Structure of the City," *Law and Contemporary Problems,* 30 (Winter, 1965), 111-119.

Berry, B.J.L., "Cities as Systems within Systems of Cities," in *Regional Development and Planning,* eds. J. Friedmann and W. Alonso. Cambridge: M.I.T. Press 1964, p. 138-153.

Berry, B.J.L., Barnum, H.G. and Tennant, R.J., "Retail Location and Consumer Behavior," *Papers and Proceedings, Regional Science Association,* 9 (1962), 65-106.

Berry, B.J.L., Goheen, P.G. and Goldstein, H., *Metropolitan Area Definition: A Re-evaluation of Concept and Statistical Practice,* Working Paper No. 28, Washington: U.S. Bureau of the Census, 1968.

Berry, B.J.L., and Pred, A., *Central Place Studies. A Bibliography of Theory and Applications,* Bibliography Series No. 1, Philadelphia: Regional Science Research Institute, 1961.

Berry, B.J.L., and Schwind, P.J., "The National Space-Economy and Urban Fields in Iowa's Urban Future" in *Proceedings of the 1967 Urban Policy Conference,* Iowa City: Institute of Public Affairs, University of Iowa, 1968.

Blalock, H.M., Jr., *Social Statistics,* New York: McGraw-Hill, 1960.

Bogue, D.J., *Metropolitan Growth and the Conversion of Land to Non-Agricultural Uses. Scripps Foundation Studies in Population Distribution, No. 11*, Oxford, Ohio, Scripps Foundation, 1956.

Borchert, J.R. and Adams, R.B., *Projected Urban Growth in the Upper Midwest: 1960-1975,* Urban Report No. 8, Minneapolis: Economic Study, 1964.

Borchert, J.R. and Adams, R.B., *Trade Centres and Trade Areas of the Upper Midwest,* Urban Report No. 3, Minneapolis: Upper Midwest Economics Study, 1963.

Bourne, L.S., *Private Redevelopment of the Central City,* Dept. of Geography Research Paper No. 112, Chicago: University of Chicago, 1967.

Bourne, L.S., *Trends in Urban Redevelopment,* Research Report No. 5, Toronto: Centre for Urban and Community Studies, University of Toronto, 1968.

Bourne, L.S. and Baker, A.M., *Urban Development in Ontario and Quebec: Outline and Overview,* Research Report No. 1, Toronto: Centre for Urban and Community Studies, University of Toronto, 1968.

Brown, L., *Diffusion Processes and Location,* Bibliography Series No. 4, Philadelphia: Regional Science Research Institute, 1968.

Bunting, T. and Baker, A.M., *Structural Characteristics of the Ontario-Quebec Urban System,* Research Report No. 3, Toronto: Centre for Urban and Community Studies, University of Toronto, 1968.

Canada, *Census of Canada, 1966. Retail Trade AM-1*, Ottawa: Census Division 1968.

Canada, Dominion Bureau of Statistics, Prices Division, Retail Prices Section, *The Consumer Price Index for Canada (1949=100) (Revised) Based on 1957 Expenditures,* Ottawa: Queen's Printer, 1961.

Carol, Hans, *The Geographical Identification of Regional Growth Centres and Development Regions in Southern Ontario,* Report to Regional Development Branch, Ontario Dept. of Economics and Developments, Nov., 1966, Mimeographed.

Carver, H., *Cities in the Suburbs,* Toronto: University of Toronto Press, 1962.

Chapin, S.F., Jr. and Weiss, S.F., *Factors Influencing Land Development,* Chapel Hill, N.C.: Institute for Research in Social Science, University of North Carolina, 1962.

Chisholm, M., *Rural Settlement and Land Use,* London: Hutchinson, University Library, 1962.

Crerar, A.D., "The Loss of Farmland in the Growth of the Metropolitan Regions of Canada," *Resources for Tomorrow, Supplementary Volume,* Ottawa: The Queen's Printer, 1962A.

Crerar, A.D., Lead-off Speaker. "Urban Growth and Resources Workshop A," *Resources for Tomorrow Conference Proceedings,* Vol. III, Ottawa: The Queen's Printer, 1962B, p. 191-195.

Cudmore, S.A., "Rural Depopulation in Southern Ontario," *Trans. of the Royal Canadian Institute,* No. 22 (Nov. 1912) Vol. ix, Part 3.

Dahms, F.A. and Pearson, N., *A Study of the Fringe Area North of Metropolitan Toronto.* Report prepared for the Central Regional Development Council. Guelph, Ont.: Dept. of Geography, University of Guelph, 1969.

Data Bank and Computer Programmes, York University, Institute for Behavioral Research, Bulletin 213, 1967.

Davies, W.K.D., "Centrality and the Central Place Hierarchy," *Urban Studies,* 4 (Feb. 1967).

Davies, W.K.D., "The Ranking of Service Centres: A Critical Review," *Trans. Institute British Geographers,* XL (Dec., 1966), pp. 67-80.

Davis, J.B. and Bourne, L.S., *Behaviour of the Ontario-Quebec Urban System: City-Size Regularities,* Research Report No. 2, Toronto: Centre for Urban and Community Studies, University of Toronto, 1968.

Doxiadis, C.A., *Emergence and Growth of an Urban Region: The Developing Urban Detroit Area,* VI, (Developing Urban Detroit Area Research Project, Detroit; Detroit Edison Co., 1966.

Duncan, O.D. and Davis, B., "An Alternative to Ecological Correlation," *American Sociological Review,* 18 (Dec., 1953) 665-66.

Duncan, O.D., Cuzzort, R.P. and Duncan, B., *Statistical Geography: Problems in Analyzing Areal Date,* Glencoe, Ill.: The Free Press, 1961.

Ellis, J.B., *A Systems Model for Recreation Travel in Ontario. A Progress Report,* D.H.O. Report No. RB126. Downsview, Ont.: D.H.O., 1967.

Ellis, J.B. and Van Doren, C.S., "A Comparative Evaluation of Gravity and Systems Theory Models for Statewide Recreational Traffic Flows," *Journal of Regional Science*, 6(1966), 57-70.

Ferres, A.L., "The 'Near' Category of Dun and Bradstreet," *Rural Sociology,* 15(1950), 175-179.

Friedmann, J. and Alonso, W., eds., *Regional Development and Planning,* Cambridge: M.I.T. Press, 1964.

Gad, G. and Baker, A.M., *A Cartographic Summary of the Growth and Structure of Cities of Central Canada.* Research Report No. 11, Toronto: Centre for Urban and Community Studies, University of Toronto, 1969.

Gaffney, M.M., "Urban Expansion--Will it Ever Stop?" in *Land, The Yearbook of Agriculture 1958.* Washington: U.S.D.A., 1958, 503-522.

Gibson, E.M.W., *A Sequent Occupance Study of the Norfolk Sand Plain with Special Reference to Urbanism.* Unpublished M.A. Thesis. London: Department of Geography, University of Western Ontario, 1963.

Goheen, P.G., *The Central Places of Southern Ontario; A Geographic Study of their External Relations.* Unpublished M.A. Thesis, Clark University, Worcester, Mass., 1964.

Golant, S. and Bourne, L.S., *Growth Characteristics of the Ontario-Quebec Urban System.* Research Report No. 4, Toronto: Centre for Urban and Community Studies, University of Toronto, 1968.

Golledge, R.G., Rushton, G. and Clark, W.A.V., "Some Spatical Characteristics of Iowa's Dispersed Farm Population and their Implications for the Grouping of Central Place Functions." *Economic Geography,* 42(1966), 261-272.

Goodman, L.A., "Some Alternatives to Ecological Correlation." *American Journal of Sociology,* 64 (May, 1959), 610-25.

Gottman, J., *Megalopolis,* Cambridge: M.I.T. Press, 1961.

Green, H.L., "Hinterland Boundaries of New York City and Boston in Southern New England." *Economic Geography,* 31 (October, 1955).

Grotewald, A., "Von Thunen in Retrospect." *Economic Geography,* 315 (October, 1959), 346-355.

Haake, J.H., *The Urban Corridors of Southeast Michigan,* Unpublished M.A. Thesis, Department of Geography, Wayne State University, 1967.

Haggett, P., *Locational Analysis on Human Geography,* London: E. Arnold, 1965.

Haggett, P. and Gunawardena, K.A., "Determination of population thresholds for settlement functions by the Reed-Muench methods." *Professional Geographer,* 26 (1964).

Harmon, H., *Modern Factor Analysis,* 2nd. ed. rev., Chicago: University of Chicago Press, 1962.

Hemmens, G.C., *The Structure of Urban Activity Linkages.* Chapel Hill, N.C.: Centre For Urban and Regional Studies, Institute for Research in Social Science, University of North Carolina, 1966.

Higbee, E., *The Squeeze Cities Without Space.* New York: Wm. Morrow, 1960.

Hill, F., *Methodological Contribution to Consumer Travel Studies: A Case Study of Elora, Ontario.* Unpublished B.A. Thesis, Waterloo: Department of Geography, University of Waterloo, 1969.

Hind-Smith, J., "The Impact of Urban Growth on Agricultural Land: A Pilot Study" in *Resources for Tomorrow;* Supplementary Volume, Ottawa: The Queen's Printer, 1961.

Hodge, G., *Comparisons of Structure and Growth of Urban Areas in Canada and the U.S.A.* Research Report No. 9. Toronto: Centre for Urban and Community Studies, University of Toronto, 1969.

Hodge, G., *Development Planning for Prince Edward Island, Rural and Urban Capability,* Toronto: Acres Research and Planning Ltd., 1967.

Hodge, G., *The Identification of 'Growth Poles' in Eastern Ontario,* A Report to the Ontario Department of Economics and Development, Toronto: Regional Development Branch, Ontario Department of Economics and Development, 1966.

Hodge, G. and Paris, J.D., *The System of Central Places Prince Edward Island,* Technical Paper, Toronto: Acres Research and Planning Ltd., 1966.

Hudson, J.C., "The Vectorial Geometry of Hinterland Organization and the Location of Towns," Paper presented at the meeting of the Association of American Geographers, St. Louis, Mo., April 12, 1967.

Hynes, C.V., "An Origin-destination study of truck traffic in Michigan." *Traffic Quarterly,* (April, 1967).

Isard, W., *Methods of Regional Analysis,* New York: Wiley, 1960. Chapter 11.

Johnston, R.J., "Central Places and the Settlement Pattern,"*Annals,A.A.G.,* 56(1966), 541-549.

Johnston, R.J. and Rimmer, P.J., "A Note on Consumer Behaviour in an Urban Hierarchy," *Journal of Regional Science,* 7(Winter, 1967), 161-167.

Jones, M.V., "Some Comments on the Current Regional Government Debate," Prepared for the Special Tax Conference, Toronto, Jan. 1968.

Kaiser, E.J., Massie, R.W., Weiss, S.F. and Small, J.G., "Predicting the Behaviour of Predevelopment, Landowners on the Urban Fringe," *Journal, American Institute of Planners,* 34(1968), 328-334.

Kaplan, H., *The Regional City,* Toronto: Canadian Broadcasting Corporation, 1965.

King, L.J., "Cross Sectional Analysis of Canadian Urban Dimensions: 1951-1961." *Canadian Geographer,* 10(1966), 205-224.

Kinneman, J.A., "Newspaper Circulation from Small Metropolitan Centre," *American Sociological Review,* 2(1946).

Kissling, C.C., *Transportation Networks, Accessibility and Urban Functions: An Emperical and Theoretrical Analysis.* Unpublished Ph.D. Dissertation. Montreal: Department of Geography, McGill University, 1967.

Kissling, C.C., "Linkage Importance in a Regional Highway Network." *The Canadian Geographer,* 13 (Summer, 1969), 113-227.

Kissling, C.C., "Accessibility and Urban Economic Activity Structure," *Proc. Fifth New Zealand Geography Conference.* 5(1968) 143-52.

Kostrowicki, J., "Geographical Typology of Agriculture Principles and Methods. An Invitation to Discussion." *Geographia Polonica* 2(1964) p. 159-168.

Lewis, E.H., *"Wholesaling in the Twin Cities."* University of Minn. Studies in Economics and Business no. 15, 1953.

Lonsdale, R.E., "Two North Carolina Commuting Patterns," *Economic Geography,* 42(1966), 114-138.

MacDougall, E.B., *Farm Numbers in Ontario and Quebec: Analyses and Preliminary Forecasts,* Research Report No. 7, Toronto: Centre for Urban and Community Studies, 1968.

Maher, C.A. and Bourne, L.S., *Land use structure and city size: An Ontario example:* Research Report No. 10. Toronto: Centre for Urban and Community Studies, University of Toronto, 1969.

Manny, Elsie, "Dun and Bradstreet as a Source of Sociological Data," *Rural Sociology,* 12(1947), 58-59.

Mark, Harold and Schwirian, Kent, P., "Ecological Position, Urban Central Place Function, and Community Population Growth." *American Journal of Sociology,* LXXIII (July, 1967) pp. 30-41.

Marshall, D.G., "Hamlets and Villages in the United States, Their Place in the American Way of Life," *American Sociological Review,* 11(1946), 159-165.

Marshall, J.U., *An Approach to the Analysis of Central Place Systems: A Study in Geographic Methodology,* Unpublished Ph.D. Thesis. Toronto: Dept. of Geography, University of Toronto, 1968.

McDonald, G.T., *Trend Surface Analysis of Farm Size Patterns in Ontario and Quebec 1951-1961.* Research Report No. 8. Toronto: Centre for Urban and Community Studies, University of Toronto, 1968.

Meier, R.L., *A Communications Theory of Urban Growth.* Cambridge, M.I.T. Press, 1962.

Metropolitan Toronto and Region Transportation Study, *Choices for a Growing Region.* Toronto: Report prepared by Community Planning Branch, Ontario Dept. of Municipal Affairs, 1967.

Miller, R.T., Zasada, G. and Channon, J.W., "The Economic Base of the Central Butte Grain Growing Region of South-Central Saskatchewan." *Canadian Farm Economics*, 2 (Feb. 1968) 14-28.

Morrill, R.L., "Expansion of the Urban Fringe: A Simulation Experiment," *Papers and Proceedings Regional Science Association,* 15, 1965A, 185-202.

Morrill, R.L., *Migration and the Spread and Growth of Urban Settlement,* Lund Series in Geography, No. 26, Lund: Gleerup, 1965B.

Murdie, R.A., "Cultural Differences in Consumer Travel," *Ec. Geog.* 41 (July, 1965) 211-234.

Nystuen, J.D. and Dacey, M.F., "A Graph Theory Interpretation of Nodal Regions," *Papers and Proceedings of the Regional Science Association.* 7(1961).

Olssen, G., *Distance and Human Interaction.* Bibliography Series No. 2, Philadelphia: Regional Science Research Institute, 1965.

Ontario Department of Municipal Affairs, *Urban Land Use in Ontario: Areas and Intensities,* Toronto: Department of Municipal Affairs. 1968.

Ottoson, H.W., et al., *Land and People in the Northern Transition Area.* Lincoln: University of Nebraska Press, 1966.

Patterson, H.L., "Ontario's Disappearing Agricultural Land," *Agricultural Institute Review,* (March-April), 1968.

Perloff, H.S. and Wingo, L., Jr., *Issues in Urban Economics,* Baltimore: The Johns Hopkins Press, 1968.

Pfouts, R.W., "Patterns of Economic Interaction in the Crescent," Chapter 2 in *Urban Growth Dynamics,* F.S. Chapin, Jr. and Shirley F. Weiss, eds. New York: Wiley, 1962.

Philbrick, A.K., *Analyses of the Geographical Patterns of Gross Land Uses and Changes in Numbers of Structures in Relation to Major Highways in The Lower Half of the Lower Peninsula of Michigan.* East Lansing: Highway Traffic Safety Centre, Michigan State University, 1961.

Pitts, F.R., ed., *Urban Systems and Economic Development,* Eugene, Oregon School of Business Administration: University of Oregon, 1962.

Plewes, M.E., *An Analysis of Urbanization in Albion Township.* Unpublished B.A., Thesis, Department of Geography, Waterloo Lutheran University, Waterloo, Ont. 1967.

Planning and Resources Institute, University of Waterloo, *The Concept of a Regional Development Plan. Progress Report: Regional Evaluation Phase,* Study Director, L.O. Gertler. Research Report Presented to the Regional Development Branch, Ontario Department of Economics and Treasury, Toronto, 1968.

Plunkett, T.J., Special Commissioner, *Peel-Halton Local Government Review,* Toronto: Report Submitted to Ontario Department of Municipal Affairs, 1966.

Ray, D.M., et al., *The Socio-Economic Dimensions and Spatial Structure of Canadian Cities.* Mimeographed report, First Phase C.M.H.C. Project, Waterloo, Ontario: University of Waterloo, 1968.

Ray, D.M., "Cultural Differences in Consumer Travel Behaviour in Eastern Ontario," *The Canadian Geographer,* 11 (3, 1967), 143-156.

Reed, H., *Work-Residence Separation of Manufacturing Workers in the Kitchener-Waterloo Area,* Unpublished M.A. Thesis. Waterloo, Ontario. Department of Geography and Planning, University of Waterloo, 1969.

Riddell, J.B., *Toward an Understanding of the Friction of Distance: An Analysis of Long Distance Telephone Traffic in Southwestern Ontario.* Unpublished M.A. Thesis, Department of Geography, University of Toronto, 1965.

Robinson, W.S., "Ecological Correlations and the Behaviour of Individuals," *American Sociological Review,* 15 (1950), 351-357.

Rushton, G., *Spatial Pattern of Grocery Purchases by the Iowa Rural Population.* Studies in Economics and Business, New Series No. 9. Iowa City, Bureau of Business and Economic Research, The University of Iowa, 1966.

Russwurm, L.H., "Expanding Urbanization and Selected Agricultural Elements: A Case Study, Southwestern Ontario, 1941 to 1961." *Land Economics,* 43 (Feb., 1967), 101-107.

Russwurm, L.H., *Expanding Urbanization in the London to Hamilton Area, Southwestern Ontario, 1941-1961,* Unpublished Ph.D. dissertation, Department of Geography, University of Illinois, Urbana, Illinois, 1964.

Salisbury, N.E. and Rushton, G., *Growth and Decline of Iowa Villages: A Pilot Study,* Iowa City: Dept. of Geography, State University of Iowa, 1963.

Schnick, D., "Development of Information Flows for Economic and Financial Policy Formulation:," *Ontario Economic Review* 6 (Nov., Dec., 1968), 4-10.

Schmid, A.A., *Converting Land from Rural to Urban Uses.* Resources for the Future, Baltimore, The Johns Hopkins Press, 1968.

Schultz, T.W., *The Economic Organization of Agriculture,* New York: McGraw-Hill, 1953.

Sellner, J.G., *The Regional Role of Galt in the Grand River Urban Triangle,* Unpublished M.A. Thesis, Department of Geography and Planning, University of Waterloo, 1969.

Semple, R.K., *A Quantitative Separation and Analysis of Spatial Trends in the Viability of Small Urban Centres in Southern Ontario,* Unpublished M.A. Thesis, Department of Geography, University of Toronto, 1966.

Senior, D., ed., *The Regional City,* London: Longmans, Green, 1966.

Sherratt, G.G., "A Model for General Urban Growth" in *Management Sciences, Models and Techniques,* Vol. 2, C.W. Churchman and M. Veerhulst, eds. New York: Pergamon Press, 1960, 147-159.

Siddall, W.R., "Wholesale-Retail Trade Ratios as Indices of Urban Centrality," *Economic Geography,* 37 (1961), 124-132.

Simmons, J.W., *Flows in an Urban Area: A Synthesis,* Research Report No. 6, Toronto: Centre for Urban and Community Studies, 1968.

Sinclair, R., " VonThunen and Urban Sprawl," *Annals, A. A. G.* 47 (March, 1967), 72-87.

Smith, D.A., "Interaction Within a Fragmented State: The Example of Hawaii," *Economic Geography,* 39 (1963), 34-44.

Smith, R.H.T., "Towards a Measure of Complementarity," *Economic Geography,* 40 (1964) 1-8.

Smith, T.L., "The Role of the Village in American Society," *Rural Sociology,* 7 (March, 1942).

Spelt, J., *The Urban Development in South Central Ontario,* Assen, Netherlands: Van Gorcum; 1955.

Sterratt, D.J., *A Factorial Typology of Ontario Agriculture,* Unpublished M.A. Thesis, Waterloo, Ontario, Department of Geography and Planning, University of Waterloo, 1969.

Straszewicz, L., "The size and structure of currency circulation as a typological criterion of towns." *Geographia Polonica* vol. 2, 1964.

Sweetser, F.L., *Patterns of Change in the Social Ecology of Metropolitan Boston, 1950-1960,* Boston: Massachusetts Department of Mental Health, 1962.

Tennant, D.B., *Urban Shadow in Toronto Gore Township: The Effects on the Rural Farm Residents,* Unpublished B.A. Thesis, Waterloo, Ontario, Department of Geography and Planning, University of Waterloo, 1968.

Thoman, R.S. and Yeates, M.H., *Delimitation of Development Regions in Canada,* Ottawa: Report to Area Development Agency, Department of Industry, 1966.

Thomas, E.N., "Some Comments on the Functional Basis for Small Iowa Towns," *Iowa Business Digest,* 31 (1961).

Thomas, E.N., Mitchell, R.A. and Blome, D.A., "The Spatial Behaviour of a Dispersed Non-Farm Population," *Papers and Proceedings Regional Science Association,* 9(1962), 107-136.

Trewartha, G.T., "The Unincorporated Hamlet," *Annals, A.A.G.* 33 (1943), 32-81.

Vance, James E., Jr., "Labor-shed, Employment Field, and Dynamic Analysis in Urban Geography," *Economic Geography,* 36 (July, 1960), 189-220.

Veldman, D.J., *Fortran Programming for the Behavioural Sciences,* New York: Holt, Rinehart and Winston, 1967.

Wakeley, R.E., *Types of Rural and Urban Community Centres in Upstate New York,* Ithaca, N.Y.: Cornell University Agricultural Experiment Station, 1961.

Walrath, A.J., *"Impacts of Changes in Land Use, A Study of an Urban-Rural Area of Southeastern Wisconsin,* ARS 43-95, Washington, U.S.D.A., 1959.

Waterloo Area Report, Toronto: Ontario Department of Municipal Affairs, 1964.

Whebell, C.F.J., "Corridors: A Theory of Urban Systems," *Annals A.A.G.,* 59 (March, 1969), 1-26.

Whebell, C.F.J., *The Geographical Basis of Local Government in Southern Ontario,* Unpublished Ph.D. Thesis, London, England: Faculty of Science, University of London, 1961.

Wheeler, J.O., "Some Effects of Occupational Status on Work Trips," *Journal of Regional Science.* 9 (April, 1969), 69-78.

Whitehand, J.W.R., "Fringe Belts: A Neglected Aspect of Urban Geography," *Trans. Inst. Br. Geogr.,* 41, (June, 1967), pp. 223-233.

Wilkinson, A., *Land Use and Traffic Flow,* Unpublished M.A. Thesis, Department of Geography, University of Toronto, 1966.

Wurster, C. Bauer, "The Form and Structure of the Future Urban Complex" in *Cities and Space,* ed. L. Wingo, Jr. Baltimore: The Johns Hopkins Press, 1963.

Winsborough, H.H., "Variations in Industrial Composition with City Size," *Papers and Proceedings Regional Science Association,* 5(1959), 121-131.

GENERAL THESES

Alderdice, K.R., *The Geography of Albion Township,* Unpublished B.A. Thesis, Dept. of Geog., McMaster University, Hamilton, Ontario, 1963.

Angst, G., *The Changing Functions of the Village of St. Jacobs,* unpublished B.A. Thesis, Dept. of Geography, University of Waterloo, Waterloo, Ontario, 1965.

Armstrong, D.J., *Fergus: an urban study,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1955.

Atcheson, P., *On Regional Evaluation of the Urban Renewal Scheme Proposed for Downtown Kitchener,* unpublished B.A. Thesis, Waterloo, Ontario, Dept. of Geography, Waterloo Lutheran University, 1968.

Barrett, F.A., *The Recreation Potential of the Niagara Escarpment (from Dundas Valley to Caledon Mt.),* Unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1958.

Bell, W.H., *Galt and Guelph: A Study in Urban Flood Problems,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1963.

Bell, Rose-Marie, *The Changing Functions of Elmira,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1965.

Breitwieser, A.J., *An Historical Geography of the Village of Erin,* unpublished B.A. Thesis, Waterloo, Ontario: Dept. of Geography and Planning, University of Waterloo, 1967.

Brown, W.S., *Caledon Township: A Geographical Survey,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1951.

Burbridge, A.A., *Guelph: A Study of Urban Growth,* unpublished B.A.Thesis, Toronto: Dept. of Geography, University of Toronto, 1953.

Cooper, M., *The Kitchener-Waterloo Fluid Milkshed,* unpublished B.A. Thesis, Waterloo, Ontario, Dept. of Geography and Planning, University of Waterloo, 1967.

Dahms, F.A., *Commuting in Waterloo County,* unpublished M.A. Thesis, London: Dept. of Geography, University of Western Ontario, 1962.

Darrell, J,A., *Economic Impact of Waterloo Universities on Retail Outlets,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo, Lutheran University, 1966.

Davey, G.H., *Kitchener: A Case Study in Industrial Geography,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1966.

Davidson, G., *The Effect of Residential Density on Public Transit Systems,* unpublished M.A. Thesis. Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1968.

Davies, L.L., *Caledon Township: A Geographical Appreciation,* unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1963.

Dean, W.G., *Toronto Township - A Geographical Reconnaissance,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1949.

Dobson, M.R., *Recreational Areas in The Humber Watershed, Ontario,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1948.

Draho, L.E., *The Location of Blight in Downtown Kitchener,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1967.

Durst, A., *Urban Growth in Waterloo Township,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, University of Waterloo, 1963.

Duxbury, J.A., *Chinguacousy and Brampton,* unpublished B.A. Thesis. Toronto: Dept. of Geography, University of Toronto, 1949.

Firstbrook, E.H., *Port Credit: A Port of the Future,* Unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1957.

Forrester, J., *Upper East Flamboro Township,* Unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1953.

Fraser, D., *Historical Geography of Wentworth County,* Unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1954.

Gallagher, D.G., *Urbanization and Urban Burlington: A Spatial Planning Point of View,* Unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1969.

Gardner, N.H., *Lower East Flamboro Township,* unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1952.

Gerland, M., *Galt: A Study in Industrial Location,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1959.

Good, D.A., *The Beechwood Residential District - A Neighbourhood Study,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1969.

Haag, G., *The Service Areas of the Lutheran Churches in Kitchener, Waterloo, Ont:* Dept. of Geography and Planning, University of Waterloo, 1963.

Haldane, Ann, *Historical Geography of Waterloo Township,* unpublished M.A. Thesis, Hamilton, Dept. of Geography, McMaster University, 1963.

Hamilton, J.W., *Stratford, Ontario - an Urban Study,* Unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1943.

Head, G., *The Township of Puslinch,* unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1963.

Heidenreich, L., *A Study of Functions and Form in Business Districts of Small Urban Centres in Southern Ontario,* unpublished M.A. Thesis, University of Toronto, 1964.

Hildebrandt, B., *Kitchener Downtown Traffic Pattern,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1967.

Hore, P., *An Analysis of the 1967 Kitchener Mall,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1968.

Jeffrey, J., *The Replacement of Galt by Kitchener as the Major Centre of the Golden Triangle,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1968.

Kirk, D.W., *Southwestern Ontario: The Aerial Pattern of Urban Settlements in 1850,* unpublished Ph.D. Thesis, Evanston, Ill, Northwestern University, 1949.

Jameson, W.M., *Caledon Township: The Physical Basis for Land Use Change, 1951-1956,* unpublished B.A. Thesis, Dept. of Geography, University of Waterloo, Waterloo, Ont.

Juurand, P., *The Influence of Perception on Orientation in Waterloo,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1968.

Koshan, E., *Locational Analysis of Super Markets in Kitchener-Waterloo,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1966.

Lang, S., *Georgetown, Acton, and Milton,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1956.

Lee, C.F., *The Middle Grand River Valley of Ontario - A Regional Study,* unpublished Ph.D. Thesis, Toronto: Dept. of Geography, University of Toronto, 1943.

Livingston, S.E., *Toronto International Airport and Urban Development,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1962.

Loch, F.J.P., *The Kitchener Rubber Industries: A Geographic Analysis,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1966.

MacKenzie, M., *North Dumfries Township,* unpublished B.A. Thesis, Hamilton, Dept. of Geography, McMaster University, 1958.

Mage, J.A.,*The Physical Basis for a Land Use Classification in Woolwich Township,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1965.

Maiers, G., *The Location of Residential Urban Blight in Kitchener, Ontario, 1961,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1964.

McCallum, J., *Burlington,* unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1957.

McKenzie, K.M., *A Manufacturing Base Analysis of Galt,* unpublished B.A. Thesis, Dept. of Geography, University of Western Ontario, 1966.

Morrow, R., Jr., *Fergus and Elora: A Comparison,* unpublished B.A. Thesis, Dept. of Geography, McMaster University, Hamilton, Ont., 1964.

McLeod, B.A., *A Study of Labour-Sheds for Selected Manufacturing Establishments in The Niagara Peninsula,* unpublished B.A. Thesis, Toronto, Dept. of Geography, York University, 1969.

Murdie, R.A., *A Geographic Study of the Mennonite Settlement in Waterloo County,* unpublished B.A. Thesis, Waterloo, Dept. of Geography, Waterloo Lutheran University, 1961.

Neal, S.F.B., *A Study of the Metropolitan Toronto Fluid Milkshed,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1962.

Nicholson, C., Jr., *A Geographic Study of the Ethnic Composition of Waterloo County,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1964.

Owen, M.R., *Nottawasaga Township, Ontario,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1950.

Patterson, M.S., *A Survey of Albion Township, Ontario,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1950.

Porter, E.F., *Nelson and Trafalgar Townships, Halton County,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1950.

Petersons, V., *Stratford and its Umland: A Central Place Study,* unpublished B.A. Thesis, Toronto: Dept. of Geography, York University, 1969.

Putnam, R.G., *Urbanization on the Toronto-Hamilton Axis: Retrospect and Prospect,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1959.

Rawls, H., *The Kitchener Market,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1965.

Rees, R., *Brampton, Ontario: An Urban Study,* unpublished M.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1960.

Renzella, L.M., *A Situation-Site Analysis of the Furniture Industry in Ontario and Kitchener-Waterloo,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1966.

Revelle, D.I., *Esquesing Township: A Geographical Appreciation,* unpublished B.A. Thesis, Dept. of Geography, McMaster University, Hamilton 1955.

Riddell, J.B., *Waterloo County: Retail Trade and Central Places,* unpublished B.A. Thesis, University of Toronto, 1963.

Rittinger, G.R., *The Changing Functions of Ontario's Urban Centres,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1964.

Russwurm, L.H., *The Rural-Urban Fringe: A Comparative Study of London, Kitchener-Waterloo, and Sarnia,* unpublished M.A. Thesis, Department of Geography, University of Western Ontario, London, Ontario, 1961.

Searth, T., *A Quantitative Analysis of Parks and Open Space in Kitchener,* Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1967.

Simpson, R.J., *The Evolution of the Central Business District of Kitchener,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1968.

Smith, H.A., *Mornington Township, Ontario,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1950.

Spriecenieks, A., *Historical Geography of Industrial Development of Kitchener Waterloo, Bridgeport, 1801-1956,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1961.

Stanford, Q.H., *Some Physical Aspects of Planning in Toronto Township,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1957.

Toiviainan, M., *A Geographical Study of Nassagaweya and Esquesing Townships,* unpublished B.A. Thesis, Toronto: Dept. of Geography, University of Toronto, 1951.

Trnavskis, B., *Waterloo Square: A Study of a Community Shopping Centre,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1967.

Toye, Beverley, *The Galt Public Market - Its Internal and External Functions,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1965.

Van Der Linde, R., *Factors Affecting the Quality of Agriculture in a Selected Area of Waterloo County: The Erbsville Area,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography and Planning, University of Waterloo, 1968.

Whitfield, P., *Toronto - Its Shrinking Newspaper Circulation Domain,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1966.

Williamson, R., *Land Use Relationships in Nassagaweya Township,* unpublished B.A. Thesis, Hamilton: Dept. of Geography, McMaster University, 1962.

Wright, G.W., *Public Utilities and Regional Government in Waterloo County,* unpublished B.A. Thesis, Waterloo, Ont: Dept. of Geography, Waterloo Lutheran University, 1968.

APPENDIX A

CLASSIFICATION DESIGNATIONS OF AMBIGUOUS OCCUPATIONS LISTED IN TOWNSHIP ASSESSMENT ROLLS

Classified as Non-Farm	Classified as Farm
Cheese Maker	Market Gardener
Fur Farmer	Farm Manager
Buttermaker	Florist
Horse Trainer	Apiarist
Drover	Nursery man
Stableman	Mushroom Farmer
Soldier (occurred only in 1941)	Sod Farmer
No occupation given (rare)	

Special Rules

1. Retired:	Farm if records indicated living with farmer; otherwise as non-farm.
2. Labourer:	A problem in some assessment rolls for 1941 because the term could refer to a hired farm worker. In 1966, almost all labourers were non-farm workers, and were so classified. For 1966 labourers were classified as farm if living as a tenant on a farm of 100 acres or over; otherwise as non-farm.
3. Widow and Spinster:	Non-farm if living alone on farm of less than 100 acres; farm if living with farmer or on property of 100 acres or more.
4. Gardener, Dairyman, Poultryman:	Farm if on property of at least 5 acres; otherwise non-farm.
5.	If sons and daughters lived at home on a farm, and had different occupations than their parents, the assessor lists their different occupation. They were then classified according to their occupation.
6.	Where population totals had to be divided because occupations indicated farm and non-farm, a fifty-fifty division was made unless the age of older family indicated children belonged to the younger family. If so, children were classified with occupation of younger family. This problem occurred only occasionally.

APPENDIX B

USE OF TOWNSHIP ASSESSMENT ROLLS FOR ANALYTICAL DATA

As has been shown in this report, data that can be used in studying the external spatial structure of cities, and that are valuable for analytical and predictive purposes, are available in the assessment rolls. Four general data categories can be derived: population, land use, land ownership, and assessment. Moreover, the township assessment rolls are the most consistently available repositories of data from past years.

Once consistent definitional criteria for the data categories have been established, the major problem in using these data is primarily one of time and cost. This appendix is used to record my experience for the benefit of future users.

For this report, data were gathered on 31 townships for both 1941 and 1966. An attempt was made to utilize, or at least evaluate, all the data. Since previous experience was not available to draw upon, the decision was made to copy the data and later to compile it for computerization. Approximately 75 weeks of work by one person were necessary to copy the data from the assessment rolls, parcel by parcel. Then, additionally, approximately 75 weeks were needed to compile the data onto coding sheets for key punching. I chose to tabulate the parcels into survey lots (around 200 acres in size). Where the land use is mainly farm, each survey lot usually consists of two parcels; however, where urban development is occurring upwards to 100 parcels or more may occur. I would now recommend that the data be directly copied from the assessment rolls onto the coding sheets by *parcels,* thus, eliminating the tedious step of compilation and saving, thereby, considerable time and effort. However, in eliminating the compilation step, the researcher must be certain beforehand exactly what data are desired and must have his coding system perfected. Pilot studies and testing of the results would thus be essential. Considerable time would also have to be expended on computer programming to compile the data to the aggregate level desired for the analysis. I chose blocks of approximately seven square miles in area, consisting of 20 to 30 survey lots. Thus, approximately 9,000 lots for the 31 townships for one year were reduced to 335 blocks. If parcels were used, I would estimate that approximately 100,000 would occur. Hence, against the saving in compilation time, must be set the added time, and cost of computerization.

The possibility of sampling in using assessment rolls merits consideration. Sampling should be feasible now that most assessment records are machine handled. The problem previously, specifically for random sampling, was how to first enumerate the population from which to sample and, second, how to find the selected members. The first problem could be overcome by using survey lots; the second problem is more troublesome, since not all the parcels for one survey lot necessarily are recorded together. Thus, considerable seeking in the assessment rolls remains a distinct possibility. With modern machine tabulation, this problem would be overcome *if* parcels are both individually coded and also survey lot coded and *if* the system of retrieval if fully operative. Thus use of survey lots is still stressed, if any comparisons over time are to be made.

APPENDIX C

COMMENTS ON THE DUN AND BRADSTREET DATA SOURCE

I

GENERAL COMMENTS

As noted in the text, the data used for the analysis of functional changes in hamlets and villages were taken from *The Dun and Bradstreet Reference Books, 1941 and 1966.* The main purpose of this reference book is the provision of credit ratings for commercial activities in settlements. In conjunction with the credit ratings, it is necessary to describe individual activities which were utilized for the functional analysis of settlements in this study.

This data source on settlements of all sizes having commercial functions has been used previously by geographers and sociologists. (Smith, 1942, Trewartha, 1943, Marshall, 1946, Manny, 1947, Ferris, 1950, Wakeley, 1961). More recently, Dun and Bradstreet data were used in geographical analyses of the functional structure of settlements. Borchert and Adams used the data in deriving a classification of functional levels for over 2,200 settlements in the Upper Midwest, and Hodge has used the data for studies on Saskatchewan, Eastern Ontario and Prince Edward Island (Borchert and Adams, 1963, Hodge, 1965, 1966A, 1966B). And Gibson, in a more aggregative way, used the data to assess functional changes of settlements, beginning with initial settlements, of the Norfolk Sand Plain, the major tobacco growing area of Western Ontario (Gibson, 1963). It is in a similar, but less aggregative way, that the data are used in the present study.

Since 1950, in addition to giving a verbal description of each commercial activity, Dun and Bradstreet have also listed commercial activities in terms of the United States Standard Industrial Classification Code. Prior to 1950, however, the listing of commercial activities was done by verbal description and a very general Dun and Bradstreet code. In order to compare the data for 1941 and 1966, it was, thus, necessary to convert the verbal description of 1941 into the S.I.C. Code used in 1966. This Appendix includes the rules used to overcome difficulties encountered in converting the verbal description into the S.I.C. Code.

According to *The Dun and Bradstreet Reporter's Guide for Using the S.I.C.,* three broad guidelines are used in making the listings of commercial activities. (1) Manufacturing, wholesaling and retailing activities are listed almost completely except for one-man operations securing their goods or materials from one source. (2) Service and similar type activities are only partially listed. Generally, one-man operations securing their goods from one source, and government and community activities are not listed. (3) Insurance, real estate, and professional activities are largely omitted. The two major exceptions are banks and operative builders (i.e. builders who sell their own buildings).

As a check on the reliability of the Dun and Bradstreet data, functions and functional units were tabulated in the field for two-thirds of the villages and hamlets. Functions and functional units are used here in the sense outlined by Thomas (Thomas, 1961) i.e., a function is each specific activity carried on in an establishment and each occurrence of a function constitutes a functional unit. Differences between the Dun and Bradstreet listings and the field check were usually minor, and only three discrepancies are worth noting. First, Dun and Bradstreet data do not consistently include activities located on highways outside the settlements. Second, Dun and Bradstreet includes more special trade contractors (painters, electricians, etc.) than were noted in the visual field check. Third, in a few cases, establishments were omitted in the Dun and Bradstreet listings. A Dun and Bradstreet official, when questioned about these omissions, stated that sometimes establishments are dropped from the listings because no interest has been shown in their credit ratings by subscribers to the reference book. Given the frame of reference under which Dun and Bradstreet operate, it is safe to say that no more than five per cent of the establishments are missed in their listings.

A different kind of problem concerning chain store branches occurs when the Dun and Bradstreet data are used for larger places. Such operations are listed only by the headquarters office unless the stores are individually owned. Hence, branch outlets are often not listed, and undercounting of functional units can result in larger places.

II

CLASSIFICATION RULES USED IN CONVERTING DUN AND BRADSTREET DATA OF 1941 INTO THE STANDARD INDUSTRIAL CLASSIFICATION

Part A

Some S.I.C. four-digit functional types had to be combined because: (1) the 1941 verbal description did not permit distinguishing between two different four-digit S.I.C. functional types; or (2) the 1941 verbal description permitted coding only to a three-digit S.I.C. functional type, but the four-digit S.I.C. functional type could be one of several possible four-digit S.I.C. functional types.

The following six combinations resulted:

1. 7538 (general auto repair) and 5541 (service station) combined as 5541;
2. 5043 (dairy wholesale) and 5451 (dairy products, retail) combined as 5451;
3. 4212 (local trucking) and 4213 (long-distance trucking) combined as 421;
4. 5462 (retail bakery with baking on premises) and 5463 (retail bakery with no baking on premises) combined as 546;
5. 5612 (men's and boy's clothing) and 5613 (men's and boy's furnishings) combined as 561;
6. manufacturing functional types were coded only to three-digit functional types.

Part B

1. Functions commonly combined in the verbal description for 1941 but listed as a single function in 1966 are as follows:

   Refreshments with service station as 5541 (service station-garage)
   Meat with groceries as 5411 (groceries)
   Confectionery with groceries as 5411 (groceries)
   Groceries and gasoline as 5411 (groceries)
   Tobacco with groceries as 5411 (groceries)
   Bakery with groceries as 5411 (groceries)
   Groceries and dry goods as 5393 (general store)
   Confectionery with tobacco as 5441 (confectionery)
   Confectionery with gas as 5441 (confectionery)
   Confectionery with bakery as 5441 (confectionery)
   Confectionery and stationery as 5441 (confectionery)
   Any retail function with general store as 5393 (general store)
   Hardware and electrical appliances as 5251 (hardware)

Flour, feed and hardware as 5251 (hardware)
Family clothing and shoes as 5651 (family clothing)
Feed and seed store as 5962 (hay, grain, feed store)
Stationery and gifts as 5943 (stationery)
Tobacco and stationery as 5993 (cigar store)
Autos as 5511 (motor vehicle dealers)
Plumbing and tinsmithing as 1711 (plumbing and heating)
Electricians as 1731 (electrical work)
Tinsmiths (unless repair function noted) as 1761 (roofing and sheet metal work)
Tobacco and billiards as 7931 (bowling, billiards, pool)
Creameries as 202 (mfg. dairy products)
Printers and publishers as 275 (commercial printing)
Sawmill and lumber as 242 (sawmills and planning mills)

2. Functions commonly combined in the verbal description for 1941 but listed as separate functions in 1966 are as follows:

0713 (grist mill) and 5962 (hay, grain, feed dealer)
5252 (agricultural implements) and 5541 (garage-service station)
5962 (hay, grain, feed dealer) and 5982 (combination fuel dealer)
5712 (furniture) and 7261 (undertaker)
5541 (garage-service station) and 7699 (blacksmith-welding)

3. Manufacturing and wholesaling only so classified when the words "manufacturing" and "wholesaling" were used in the verbal description for 1941.

APPENDIX D

VILLAGE FUNCTIONAL UNITS

	S.I.C. Code	Functional Class
Central Place	0713	Grist mills
	50	Wholesaling
	52	Building materials, hardware, farm equipment
	5393	General stores
	53	General merchandise
	5411	Grocery stores
	5422	Meat markets
	54	Other food
	5541	Service station-garages
	55 & 75	Other automotive services
	56	Apparel and accessories
	57	Furniture and home furnishings
	58	Eating and drinking places
	5962	Hay, grain and feed stores
	598	Fuel and ice dealers
	59	Other miscellaneous retail stores
	603	Banks
	7011	Hotels-motels
	72	Personal services
	7699	Blacksmith and welding shops
	76	Miscellaneous repair services
	78 & 79	Amusement and recreation services
Non-Central Place	17	Special trade contractors
	42 & 48	Transportation and communication
	20	Manufacturing-food
	22 to 38	Manufacturing-other.

VILLAGE FUNCTIONAL UNITS
1941

S.I.C. CODE	CENTRAL PLACE																					NON-CENTRAL PLACE				
	0713	50	52	5393	53	5411	5422	54	5541	55 & 75	56	57	58	5962	598	59	603	7011	72	7699	76	78 & 79	17	42 & 48	20	22 to 38	total
Aberfoyle	1					1			1											1					1	1	6
Alma	1			1		1			1					1	2		1			1							9
Alton			1	2		1	1	2	1					1		2	1	1	1	1	1					2	18
Ayr	2		6	1		3	1	3	2	1	1	2	1		2	5	1	1	2	1	1		2	1	3	2	44
Baden		1	2	2		1	1		3	2		1		1		2		2	1	1	2		1		2	2	27
Ballinafad	1			1						1										1							4
Belwood				1		1			1											1				1			5
Blair				1		1												1							1		4
Bloomingdale	1			2																1							4
Bolton			8	2		2	1	3	3	1	2	1		1	2	2	1	1	2	1	1		2	1	2	1	40
Branchton				1											1		1										3
Breslau	1			2		1			2						1	1		1		1						1	11
Bridgeport	1			1		2	1		1						1			1					1			1	10
Caledon	1		2	2			1		3		2						1	1		1							14
Caledon East	1			2		1	1	1	3	2		1			1		1	1	1	1					1		18
Campbellville	1			3				1	3	1		1		1	1		1			2						3	18
Carlisle				1		1			1					1			1			1							6
Cheltenham				1			1													1							3
Conestogo			2	3												1		1		2	2				1	1	13
Doon				2		1				1																	4
Drayton	2		3			4	2	3	1	1	2	2		2	1	2	1	1	3	2			2		1	1	36
Eden Mills	1			2																1							4
Elora	2		6	1	1	6	2	3	2			1	1	1	3	2	2		2	1	1	1	2		2	1	43
Erin	1		6	2	1	5	1	3	3		1	1		1	2	2	1	1	2	2						3	38
Floradale	1			2						1										2						1	7
Gadshill										1		1						1		1							4
Glen Allan				2		1				1								1		1							6
Glen Williams				1					1														1		2	2	7
Hawkesville	1		1	2																1	1						6
Heidelberg				1							1									3							5
Hillsburgh	3		4	5		2	1	1		2		1			1	1	1		2	1				1		1	27
Huttonsville				1		1			1																	1	4
Inglewood	1		1	4		1		2							1			1		1			1			1	14
Limehouse				1																1						1	3
Linwood	1		1	2			1	1	1	2	1	1		2	1		1	1			1		1				18
Malton	1	1		1		2			5				1		2		1	1			1	1				1	18
Marsville	1			1					1											1							4
Maryhill	1			2										1				2		1							7

VILLAGE FUNCTIONAL UNITS *(continued)*
1941

	CENTRAL PLACE																					NON-CENTRAL PLACE				
S.I.C. CODE	0713	50	52	5393	53	5411	5422	54	5541	55 & 75	56	57	58	5962	598	59	603	7011	72	7699	76	78 & 79	17	42 & 48	20	22 to 38	total
Meadowvale	1			1																1							3
Millbank	1			1		1								2	1					1	1				2	1	11
Milverton	2		6	3		2	2	3	4		2	1	1	1	2	2	2	1	2	2	1	2	2		1	3	47
Mono Mills	1			1																1							3
Mono Road	1			1				1							1												4
Moorefield	1		2	2		2	1	1	3		1			2	1	1				1	1	1					20
Morriston				2		1	1										1				1		1				7
New Dundee	2	1	1	2				1	1	2		1		1				1	2	3	1					3	22
New Hamburg			4	1		4	3	2	8	3	2	1		2	3	4	1	3	2	2	1	1	1		7	3	58
Newton				1		1														2						1	5
Norval	1		1	1		1			1			1			1			1		1							9
Orton	1			1					2						1									1			6
Ospringe	1			1																1							3
Palermo				1					1	1										1							4
Palgrave	1			3		1	1										1	1									8
Petersburg	1	1	1	1					1	1				1	1			1		1						2	12
Puslinch				1					1						1												3
Rockwood	2	2	2	1		1	1	1	2	1		1		2	1		1		1	1						2	22
Rostock	1			2										2											3		8
Rothsay	1			2																							3
St. Agatha				1														2					1		1		5
St. Clements	1		3	2			1			1							1			1						3	13
St. Jacobs		3	1	2			1	3	2	1	2			1	1		1	1	1	3		1	2		2	6	34
St. Pauls	1			1						1										2							5
Salem	1			1					1	1				1						1							6
Sandhill	1			1					1																		3
Sebringville	2			2			1	2	1	1	1	1	2	1	1		1		1	1	1						19
Shakespeare	1	1	1	3			1		1								1	1		1				1			12
Snelgrove	1			1										1	1					1							5
Tavistock	1	1	7	2	1	3	4	4	8	3	3	5		1	2	5	1	2	2	2			2		2	3	64
Terra Cotta				1		2																					3
Victoria				1					1											1						1	4
Wallenstein	1			1																			2	1	1	3	9
Waterdown			1	1		2	1	2	6		1			1	2	2	1	2		1	1		1			1	26
Wellesley	2	1	4	3		2	1	1	3		3	1		2		2	1	2	4	3	3						38
West Montrose				1					1											1							3
Winterbourne	1			1					1																		3

VILLAGE FUNCTIONAL UNITS
1966

S.I.C. CODE	CENTRAL PLACE																					NON-CENTRAL PLACE				
	0713	50	52	5393	53	5411	5422	54	5541	55 & 75	56	57	58	5962	598	59	603	7011	72	7699	76	78 & 79	17	42 & 48	20	22 to 38	total
Aberfoyle				1					2				1														4
Alma	1		1	3		1		1	4				1		1											1	14
Alton				2						1							1			1			2	2		3	12
Ayr	1	1	6	2		1	1		2	3	1	2	3	3		4	1						4			4	39
Baden		1	2	2		1		1	2	1		1					1	1		2			4	1	2	3	25
Ballinafad	1			1					1																		3
Belwood			1	1					1	1																	4
Blair	1		1			1			1																	1	5
Bloomingdale							1		1	1																1	4
Bolton		5	8	1	3	3		1	6	3	3			1		4	1		1			1	12	3	6	8	70
Branchton		1	1	1												1								1		1	6
Breslau		1	1	1		1	1	1	3				1										6	2		3	21
Bridgeport			1			1	2		1			1	1	1	1	1	1	1					5	3		5	25
Caledon				1		1			5			1					1	1		1			3	3	1	1	19
Caledon East		1	1	2		1	1		2	1				1		2	1								1	1	15
Campbellville			1	3	1				3			1	1				1						4			1	16
Carlisle				1					1			1					1			1							5
Cheltenham		1	1	1																					1		4
Conestogo				2					1					1		1		1					2	1	1		10
Doon				2					1				1										3				7
Drayton	2		3	2	1	2		1		1	3	2	1			3	1		1	1			2	1	2	1	30
Eden Mills				1					1																	1	3
Elora	2		5	1		4	2	1	3		1	2	1	1	1	3	1	1	1				9	1	1	5	46
Erin	1	1	4		2	2	3	4	4	1	2	2	1	2	1	4	1	2	1			1	3	2		2	46
Floradale	1	1	1	2																			1			2	8
Gadshill				1					1									1									3
Glen Allan	1			2					1																		4
Glen Williams				1		1							1												3		6
Hawkesville			2	1	1				1														1			3	9
Heidelberg				1						1								1							1	1	5
Hillsburgh		1	5	4		1			2		1	1		1									3			3	22
Huttonsville						2			1							1							1				5
Inglewood		1	3	1		1			2							1	1						2			1	13
Limehouse			2	1																						1	4
Linwood	1		2	1	1	1			1			1		3			1						2	2		5	21
Malton		15	5		3	1		2	13	4			5			7	2	2			1		12	1	1	19	93
Marsville	1			1														1									3
Maryhill	1			2									2											1		1	7

VILLAGE FUNCTIONAL UNITS *(continued)*
1966

S.I.C. CODE	CENTRAL PLACE																					NON-CENTRAL PLACE				
	0713	50	52	5393	53	5411	5422	54	5541	55 & 75	56	57	58	5962	598	59	603	7011	72	7699	76	78 & 79	17	42 & 48	20	22 to 38	total
Meadowvale				1					1	1																1	4
Millbank			3	1	1	1						1				1							1		1	1	11
Milverton			6	2		1	3	1	1	1	1		1	2		2	2					1	1	1	2	4	32
Mono Mills			1						2																		3
Mono Road			1	1											1												3
Moorefield			2	1		1	1	1	2				1	3	1	2				1		1	1		1		19
Morriston			1	1					2			1											1				6
New Dundee	1		3	1		3				1		1		1			1	1					2		1	1	17
New Hamburg			5	1	2	5		4	8	4	2	4	1	1		5	2	1	1				5	1	3	6	61
Newton	1			2																			3				6
Norval			2	1					2	1			3			1		2					5			1	18
Orton				2					1																		3
Ospringe				1					1	1						1											4
Palermo				1					3																		4
Palgrave	1			2					2								1						1			1	8
Petersburg		1	2	1	1				2			1				1		1					3	1		2	16
Puslinch				1					1				1	1		2							1				7
Rockwood	3	2	5		2	1		2	2	1	1		1	3	1	1	1								1	5	32
Rostock	1	1	1	2					1																1		7
Rothsay		1		1			1		1																		4
St. Agatha			2	1					3				2										2				10
St. Clements				1						1		1		1			1						1			3	9
St. Jacobs		3	4	2	1		1	1	3	1		1		1		1	1				1		2		4	8	35
St. Pauls				1																	1		2				4
Salem			1	1					1							1											4
Sandhill			1	1					1																		3
Sebringville	1	1	1	1		1		1	2	1	1	1	1	1		1	1						4			1	20
Shakespeare	1		1	1					2				1				1					1	1			2	11
Snelgrove									1							1							1				3
Tavistock		3	5		2	3	2	3	4	2	1	4	1	1	1	3	1	1	1	1	3	1	5	3	4	4	59
Terra Cotta				1												1											2
Victoria			1	1									1														3
Wallenstein	1			3										2						1						2	9
Waterdown		3	3	1		4		1	5	2	3	1	5	1		5	1	3	2	1	1	1	4		3	7	57
Wellesley	1	2	8	2		1	1	1	1		2			2		2	1		1				2		1	1	29
West Montrose				1					1											1							3
Winterbourne				1					1											1							3

APPENDIX E

FACTOR SCORES, VILLAGE FACTOR ANALYSIS

Village	1941 Factor 1	1941 Factor 2	1941 Factor 3	1941 Factor 4	1966 Factor 1	1966 Factor 2	1966 Factor 3
Aberfoyle	–0.35	–0.54	–0.05	0.09	–0.43	–0.41	–0.43
Alma	–0.08	–0.51	–0.44	0.75	–0.26	–0.65	0.60
Alton	–0.11	0.94	0.04	0.03	0.14	–0.88	–0.41
Ayr	1.43	0.45	–0.62	0.88	1.04	0.32	1.01
Baden	0.03	2.73	0.63	–1.19	0.17	–0.26	–0.93
Ballinafad	–0.36	–0.46	–0.15	–0.60	–0.53	–0.25	–0.34
Belwood	–0.57	–0.82	–0.19	–0.48	–0.35	–0.16	–0.49
Blair	–0.33	0.08	–0.77	–0.22	–0.50	–0.02	–0.36
Bloomingdale	–0.50	–0.48	–0.20	–0.35	–0.48	–0.00	–0.58
Bolton	1.19	0.92	0.03	–0.27	2.90	3.16	–0.26
Branchton	–0.29	–0.76	–0.57	0.41	–0.22	–0.39	–0.24
Breslau	–0.19	–0.07	–0.23	–0.08	0.57	–0.78	0.24
Bridgeport	0.13	–0.41	–0.55	0.33	0.34	–1.56	2.27
Caledon	–0.14	0.02	–0.36	–0.15	0.23	–0.68	–0.71
Caledon East	0.96	0.29	–0.11	–0.95	0.17	–0.16	0.39
Campbellville	–0.17	–0.46	1.34	–0.09	0.55	–0.52	–0.58
Carlisle	–0.30	–0.23	–0.28	0.13	–0.56	–0.49	–0.54
Cheltenham	–0.25	–0.60	–0.23	–0.04	–0.43	–0.10	–0.38
Conestogo	–1.09	2.08	–0.26	–0.54	–0.28	–0.34	–0.14
Doon	–0.28	–0.34	–0.56	–0.52	–0.28	–0.46	–0.46
Drayton	2.08	0.33	0.23	–0.45	–0.55	2.94	–1.20
Eden Mills	–0.58	–0.38	–0.26	–0.33	–0.48	–0.32	–0.40
Elora	2.63	–1.37	–1.26	3.96	0.13	1.16	1.60
Erin	2.72	–1.82	0.26	0.38	–0.06	1.49	3.55
Floradale	–0.71	–0.46	0.45	–0.37	–0.20	–0.39	–0.28
Gadshill[a]	0.03	–0.26	–0.19	–1.08			
Glen Allan	–0.29	0.09	–0.26	–0.85	–0.58	–0.24	–0.33
Glen Williams	–0.58	–0.28	0.22	0.28	–0.60	0.41	–0.60
Hawkesville	–0.79	0.44	–0.55	–0.25	0.12	–0.33	–0.35
Heidelberg	–0.51	–0.29	0.59	–0.77	–0.47	–0.09	–0.64
Hillsburgh	0.71	–0.66	–0.28	–0.68	0.24	0.27	–0.18
Huttonsville	–0.37	–0.60	–0.31	0.01	–0.57	0.18	–0.60
Inglewood	–0.32	–0.27	0.17	–0.01	0.21	–0.18	–0.34
Limehouse	–0.50	–0.48	–0.20	–0.35	–0.44	–0.20	–0.27
Linwood	0.36	1.36	–0.21	–0.70	0.71	–0.59	0.91
Malton	–0.54	0.13	–0.01	3.13	6.63	–2.34	–0.89
Marsville	–0.44	–0.48	–0.27	–0.25	–0.71	–0.25	–0.40
Maryhill	–0.52	0.80	–0.39	–0.65	–0.39	–0.41	–0.23
Meadowvale	–0.45	–0.55	–0.62	–0.11	–0.31	–0.27	–0.54
Millbank	–0.72	1.24	–0.41	0.52	–0.12	0.43	–0.53
Milverton	0.54	1.00	0.96	3.98	0.25	0.39	3.30
Mono Mills	–0.50	–0.52	–0.26	–0.26	–0.43	–0.25	–0.38
Mono Road	–0.26	–0.80	–0.57	0.20	–0.72	–0.65	0.68
Moorefield	–0.08	1.27	–0.57	1.24	–1.02	–0.37	3.15
Morriston	–0.39	0.29	–0.87	0.31	–0.37	–0.18	–0.52
New Dundee	–0.45	0.71	2.38	–1.32	–0.20	0.65	–0.37
New Hamburg	2.13	3.85	0.41	0.84	1.83	3.54	–1.67
Newton	–0.51	–0.59	0.40	–0.31	–0.38	–0.31	–0.38
Norval	0.13	–0.35	–0.54	–0.36	0.06	–0.55	–0.65
Orton	–0.17	–0.88	–0.80	0.14	–0.48	–0.32	–0.43
Ospringe	–0.50	–0.48	–0.20	–0.35	–0.36	–0.16	–0.54
Palermo	–0.30	–0.38	–0.09	–0.68	–0.36	–0.37	–0.48
Palgrave	–0.23	–0.02	–0.82	–0.02	–0.06	–0.48	–0.33
Petersburg	–0.41	–0.32	1.40	–0.27	0.38	–0.41	–0.54
Puslinch	–0.34	–0.63	–0.60	0.06	–0.37	–0.34	–0.02
Rockwood	0.25	–1.00	2.27	0.12	1.00	0.06	2.02
Rostock	–0.69	0.98	–0.71	0.14	–0.32	–0.12	–0.35
Rothsay	–0.54	–0.41	–0.62	–0.17	–0.46	–0.52	0.19
St. Agatha	–0.36	0.48	–0.60	–0.39	–0.14	–0.31	–0.41
St. Clements	–0.30	–0.81	0.87	–0.05	0.02	–0.39	–0.16
St. Jacobs	–0.63	–0.84	6.38	1.28	1.59	–0.17	0.55
St. Pauls	–0.40	–0.44	0.21	–0.75	–0.49	–0.39	–0.26
Salem	–0.32	–0.05	–0.15	–0.55	–0.45	–0.19	–0.36
Sandhill	–0.45	–0.51	–0.51	–0.20	–0.48	–0.24	–0.36
Sebringville	–0.20	0.57	–0.97	1.79	0.26	0.29	–0.26
Shakespeare	–0.34	–0.56	0.45	0.32	–0.34	–0.23	0.68
Snelgrove	–0.41	–0.27	–0.31	0.03	–0.46	–0.23	–0.42
Tavistock	5.65	–1.08	0.46	–2.66	0.61	1.56	2.46
Terra Cotta	–0.14	–0.71	–0.79	–0.04	–0.71	–0.21	–0.46
Victoria[b]					–0.57	–0.38	–0.15
Wallenstein	–0.53	–0.65	–0.26	0.00	–0.59	–0.63	0.32
Waterdown	0.69	0.92	0.24	0.88	–0.43	3.43	–0.73
Wellesley	0.12	3.97	0.69	–0.95	–0.12	1.82	0.96
West Montrose[c]							
Winterbourne[c]							

[a] not included in 1966.

[b] not included in 1941.

[c] not included in 1941 or 1966.